SCIENTIFIC AMERICAN SUPPLEMENT. No. 1582

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Copyright, 1906, by Munn & Co.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXI., No. 1582. NEW YORK, APRIL 28, 1906. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

FIG. 1.—AN ELECTRIC CRANE USED FOR LIFTING LOCOMOTIVES IN A RAILROAD SHOP IN SILESIA, GERMANY.

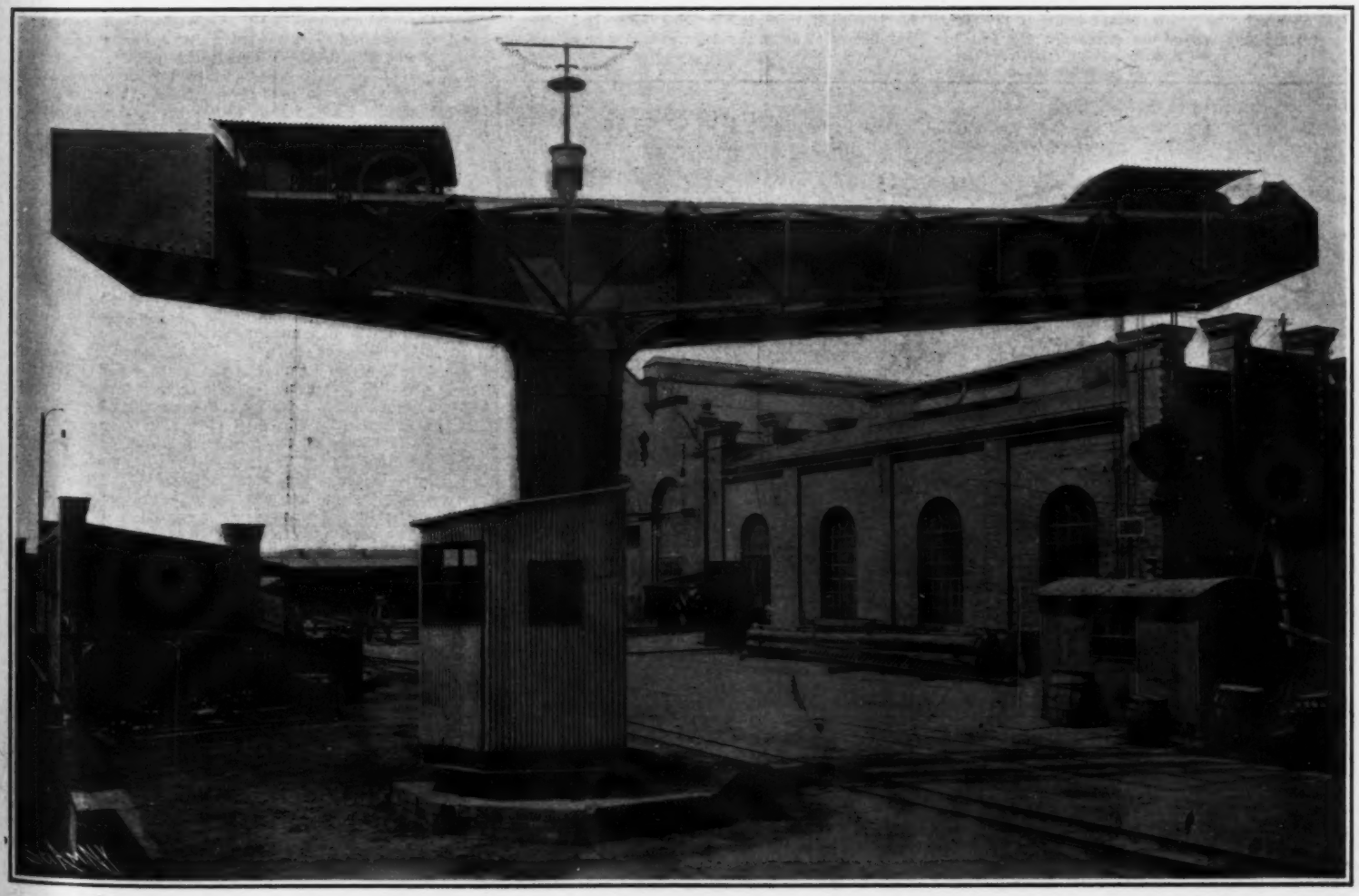


FIG. 2.—A GERMAN ELECTRICALLY-OPERATED ROTARY CRANE.

SOME GERMAN ELECTRICALLY-OPERATED CRANES.

SOME GERMAN ELECTRICALLY-OPERATED CRANES.*

By DR. ALFRED GRADENWITZ.

IN view of the ever-increasing use of electricity in connection with the operation of cranes, the following description of some typical cranes, the electrical part of which was designed by the Siemens-Schuckert works, should be of interest to American engineers.

The locomotive-lifting crane represented in Fig. 1 was built for a Silesian locomotive shop, and has a lifting capacity of 110,000 pounds, with a span of 37½ feet. Direct current at 220 volts is used for the electrical operation of the apparatus. Each of the two crabs of 35 tons bearing capacity is equipped with a shunt motor of 7.6 horse-power running at 625 revolutions per minute. To actuate the stopping brake there is an angular-lever braking magnet provided with a shunt coil; this is switched on by means of the lifting controller. For the automatic cut-out at the highest position of the hook a double-pole switch is used. This switch has to be put in again by hand. The two lifting gears are regulated by a hand-lever controller fitted with a suitable resistance, and the lever of which has a horizontal zero position. The resistance of the controller has been so designed that any motion can be effected without shock. The shunt coil of the lifting motor is switched in on inserting the main controller switch, which has been designed as a hand-magnet switch. Between the controller and the two lifting motors have been arranged two lever switches, to allow either of the lifting motors to be switched out.

The crane traveling gear is provided with a series motor the output of which is 11 horse-power with a speed of 750 revolutions per minute. This motor is controlled by means of a vertical lever controller with suitable resistance. An angular-lever breaking magnet supplied with a series coil is used in connection with it.

The steering apparatus and the simple switchboards on which all necessary safety devices, in addition to a main cut-out, have been mounted, are fitted to the driver's stand, which is suspended from the crane. The mechanical part of this locomotive-lifting crane has been designed by Messrs. Zobel, Neubert & Co., of Schmalkalden.

A free rotary crane provided with three direct-current motors is represented in Fig. 2. This crane has a capacity of 27,500 pounds.

An electrically-operated rotary tower crane of 75 tons capacity, which was recently supplied for the harbor of Hamburg, is shown in Fig. 3. This crane, the mechanical part of which was designed by the Vereinigte Maschinenfabrick Augsburg und Maschinenbaugesellschaft Nürnberg A. G., is used in the loading and unloading of ship and railway goods. Its maximum reach is nearly 99 feet for the auxiliary winch, with a lifting capacity of 16,500 pounds, 94 feet with a load of 99,000 pounds, 75 feet for a capacity of 165,000 pounds, and 75 feet for the experimental load of 220,000 pounds. The lifting height is about 117 feet.

The working speeds of the crane are 4½ feet per minute in lifting a load of 75 tons, 18 to 24 feet per minute in lowering the empty hook, 30 feet per minute in lifting a load of 7.5 tons, and finally 24 to 27 feet per minute in moving a load of 7.5 tons. A full swing of the crane is accomplished in about five minutes.

The electric motors work at a tension of 450 volts, and have the following outputs: The main lifting motors 2 x 22.5 horse-power at 290 revolutions per minute in series or 580 revolutions per minute in parallel; the auxiliary lifting motor, 30 horse-power at 730 revolutions per minute; the traveling motor, 24 horse-power at 850 revolutions per minute; and the slewing motor, 19 horse-power at 1,250 revolutions per minute.

The winches for the higher loads and for the crab travel are located in an engine house on the back arm of the outrigger, while the auxiliary winch is placed on the crab. The engineer's cab, whence all the motions of the crane are controlled, is arranged in the front arm of the outrigger. The crane is provided with an entirely self-contained electrically-driven auxiliary device to discharge, by means of a hopper fitted to the crane, the full load of a coal wagon into any suitable barge.

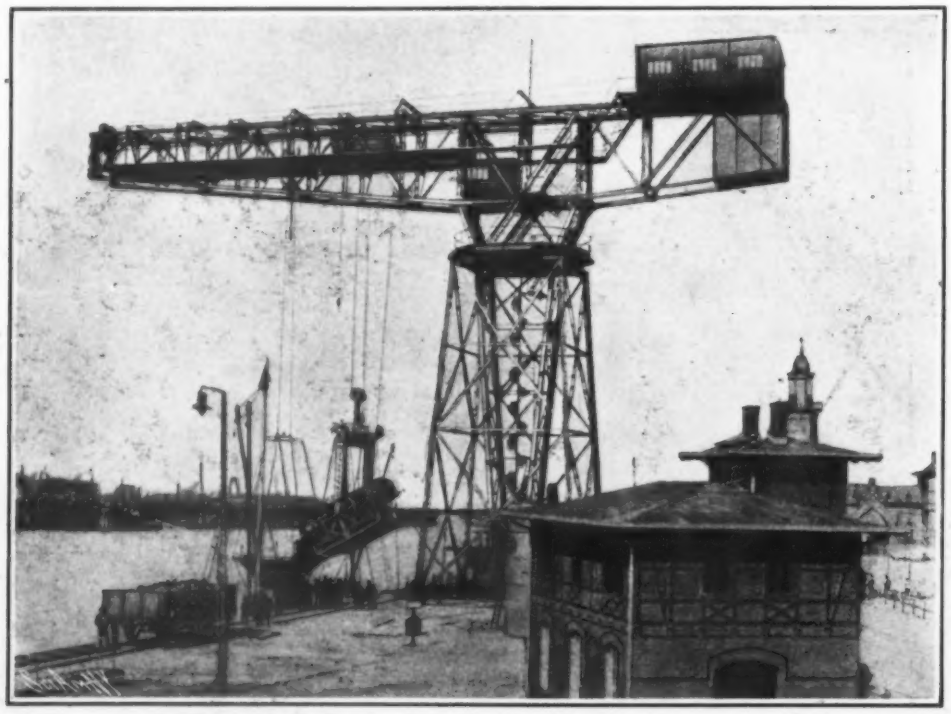


FIG. 3.—ELECTRICALLY-OPERATED ROTARY CRANE USED AT HAMBURG HARBOR.

The Siemens-Schuckert works in the course of last year supplied, in conjunction with the Nuremberg Machine Company, a number of lifting and transporting devices required for the coal stores established in the new Main harbor at Offenbach, Germany. These include three loading bridges, a transportable gantry crane of 4 tons lifting capacity, and six electrically-operated winches. A general view of this coal-transporting plant is given in Fig. 4.

The bridges, besides the loading of pieces, are mainly used in conveying the coal from the ships to the cars placed immediately behind the quay wall, as well as to horse vehicles and to the stores. They are transported by means of an inclosed series motor of 20 horse-power capacity running at 1,400 revolutions per minute.

The lifting gear of the loading bridge is actuated by a motor of about 45 horse-power at 600 revolutions per minute. This motor transmits its power by means of a rawhide gear and a cast-iron wheel, and thence through cast-steel spur-wheel gearing to the lifting drum. The slewing gear is operated by an inclosed series motor of 3.5 horse-power at 700 revolutions per minute.

The crane truck is conveyed along the loading bridge by means of an inclosed series motor of 16 horse-power at 1,400 revolutions per minute. This rests on a bracket fitted to the back end of the crane truck, and the drive is through multiple worm and spur-wheel gearing on the back pair of running wheels. Braking is effected by electricity through a short-circuit armature brake as well as by means of a mechanical brake placed on the worm-shaft and operated from a braking magnet.

The engineer's cab contains a marble switchboard provided with safety fuses, cut-outs, an automatic high-tension switch, and an ammeter. In the cab there are also installed the motor starters. A common controller with switch serves for the crane-traveling and bridge-traveling motors. Direct current at about 580 volts is available for the operation of the bridge, and is supplied through flexible cables to the girder located on the waterside. The cable is automatically wound up as the bridge is transported, the contacts having to be exchanged only at intervals of over 200 feet. A similar arrangement serving the same purpose is used in connection with the gantry crane. This consists principally of a drum on which the cable is automatically wound up and whence the current is supplied through a sliding ring.

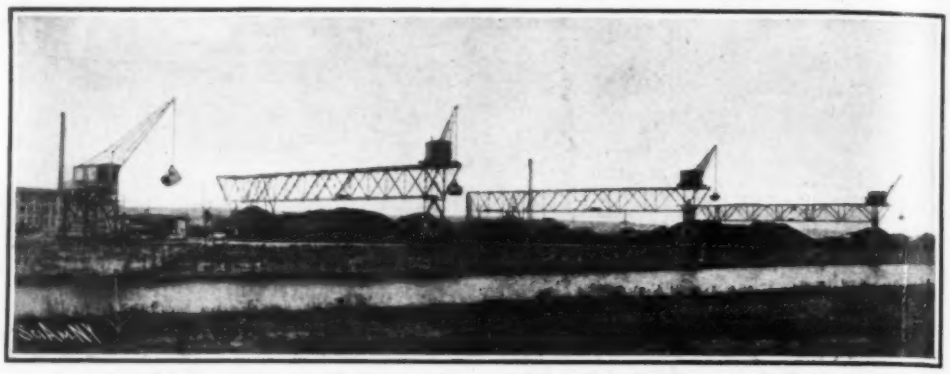


FIG. 4.—GERMAN COAL-HANDLING PLANT AT THE HARBOR OF OFFENBACH.

The whole plant is completed by six electrically-operated winches, each of 1,650 pounds capacity, with a speed of the cable of 1½ feet per second. These are actuated by series motors of 7.5 horse-power each when running at 500 revolutions per minute, and they are steered by pedal-operated starters.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE RISE OF ELECTROSTATICS.

COULOMB'S (1785) law antedates the century; indeed, it was known to Cavendish (1771, 1781). Problems of electric distribution were not seriously approached, however, until Poisson (1811) solved the case for spheres in contact. Afterward Clausius (1852), Helmholtz (1868), and Kirchhoff (1877), examined the conditions for disks, the last giving the first rigorous theory of the experimentally important plate condenser. In 1845, 1848 the investigation of electric distribution received new incentive as an application of Kelvin's beautiful method of images: Maxwell ("Treatise," 1873) systematized the treatment of capacity and induction coefficients.

Riess (1837) in a classic series of experiments on the heat produced by electrostatic discharge virtually deduced the potential energy of a conductor and in a measure anticipated Joule's law (1841). In 1860 appeared Kelvin's great paper on the electromotive force needed to produce a spark. As early as 1855, however, he had shown that the spark discharge is liable to be of the character of a damped vibration and the theory of electric oscillation was subsequently extended by Kirchhoff (1867). The first adequate experimental verification is due to Feddersen (1858, 1861).

The specific inductive capacity of a medium with its fundamental bearing on the character of electric force was discovered by Faraday in 1837. Of the theories propounded to account for this property the most far reaching is Maxwell's (1865), which culminates in the unique result showing that the refraction index of a medium is the square root of its specific inductive capacity. With regard to Maxwell's theory of the Faraday stress in the ether as compared with the subsequent development of electrostriction in other media by many authors, notably by Boltzmann (1880) and by Kirchhoff (1885), it is observable that the tendency of the former to assign concrete physical properties to the tube of force is growing, particularly in connection with radioactivity. Duhem (1892, 1895) insists, however, on the greater trustworthiness of the thermodynamic potential.

The seemingly trivial subject of pyro-electricity interpreted by Æpinus (1756) and studied by Brewster (1825), has none the less elicited much discussion and curiosity, a vast number of data by Hankel (1839-93) and others and a succinct explanation by Kelvin (1860, 1878). Similarly piezoelectricity discovered by the brothers Curie (1880), has been made the subject of a searching investigation by Voigt (1890). Finally Kerr (1875, *et seq.*) observed the occurrence of double refraction in an electrically polarized medium. Recent researches, among which those of Lemoine (1896) are most accurate, have determined the phase difference corresponding to the Kerr effect under normal conditions, while Voigt (1899) has adduced an adequate theory.

Certain electrostatic inventions have had a marked bearing on the development of electricity. We may mention in particular Kelvin's quadrant electrometer (1867) and Lippmann's capillary electrometer (1873). Moreover, among apparatus originating in Nicholson's duplicator (1788) and Volta's electrophorus, the Töpler-Holtz machine (1865-67), with the recent improvement due to Wimshurst, has replaced all others. Atmospheric electricity, after the memorable experi-

men of Franklin (1751), made little progress until Kelvin (1860) organized a systematic attack. More recently a revival of interest began with Exner (1886), but more particularly with Linss (1887), who insisted on the fundamental importance of a detailed knowledge of atmospheric conduction. It is in this direction that the recent vigorous treatment of the atmosphere as an ionized medium has progressed, owing chiefly to the indefatigable devotion of Elster and Geitel (1899, *et seq.*) and of C. T. R. Wilson (1897, *et seq.*). Qualitatively the main phenomena of atmospheric electricity are now plausibly accounted for; quantitatively there is as yet very little specific information.

HOW A GREAT TELEPHONE SYSTEM IS DESIGNED.*

By J. J. CARTY.

LET us take the case of New York city, with the suburban territory tributary to it, and assume that it is the intention of the telephone company to install within that territory a telephone system which will work at a proper degree of efficiency and at the same time yield to the investor a fair return upon his investment; and that it is necessary not only that this condition should exist during the first stages of the project, but that the undertaking should be so managed that this condition will be maintained indefinitely. With such a problem before the telephone management, what part of it should the management require the telephone engineer to work out? I shall answer this question by describing, in general terms, and sometimes, for the purposes of illustration, in considerable detail, what should be the work of the telephone engineer, in such a case.

The first question which the engineer must decide is, What is the period for which such construction as may be required should be planned? This is a question of far-reaching importance and requires for its answer that a vast amount of data should be collected, and that careful and long-continued study and investigation should be given to a large number of factors involving, among other things, first cost and character of construction of the diverse portions of a plant of such complicated nature, annual charges such as maintenance, depreciation, and interest, and local conditions bearing upon the possibility of the renewal or extension at some future time of all of the elements of the plant.

In addition to this, due regard must be paid to possible changes in the art, and also the fact that, owing to the exigencies of the business, many cases arise where it is necessary to carry out at the beginning, especially in underground work, all of the construction which may ever be needed.

At the outset the question of the period for which to plan depends upon the expectations of growth. With a given expectation of growth, the engineer, by taking into account all of the factors of the case, and balancing the annual charges resulting from the initial investment against the cost of reconstruction and rearrangement of the plant at some future time, arrives at the economical period for which to plan.

In this work the predictions as to growth are of the first importance, and, inasmuch as accurate predictions of this kind are attended with the greatest difficulty, it is essential that not only the judgment of the engineer, but that of the business management and all others who might be able to advise in connection with the matter, should be obtained.

At this stage of the work it is of the utmost importance that the bearing of these estimates of growth upon the future of the plant should be thoroughly understood by the business management, whose functions, in the nature of the case, exercise such a profound effect upon the extent and character of such growth. It is the duty of the engineer to make this point clear and to obtain from the business management serious and responsible estimates of future growth.

The number of lines which may be expected having been agreed upon, the question of for how long a period ahead we should plan is determined by a number of circumstances. For such conditions as obtain at New York, the period for much of the construction has been found to be from seventeen to twenty years. This figure is arrived at by taking into account a large number of factors, such as life of the central-office switchboard, which is placed at about fifteen years, the relative costs of placing in the subways a large number of ducts initially as compared with adding new ducts after a period of about twenty years, the uncertainty regarding the changes in the state of the art, and the difficulty of foretelling with sufficient detail conditions which are expected to obtain during a period so far ahead as twenty years.

In the case chosen for illustration, which was New York, the economical period was found to be about twenty years, and it was attempted to plan for conditions which would obtain in the year 1920, and for each year up to that date. The total number of lines to be provided for in the island of Manhattan is 300,000. The working out of the general plans for providing for this number of lines, which it was expected would be reached by the year 1920, constitutes what is known as the "300,000-line study." To give an idea of the nature of part of the work of the telephone engineer, I shall outline in general terms the character of this study.

Having determined upon 300,000 lines as the proper foundation of the study, and having received the proper authorization from the business management to proceed on that basis, the next step is to plot on a map the probable distribution of these lines. This is done, not by giving the location of each line, but by indicating by blocks the most probable distribution. Here again the judgment of the engineer must be assisted and directed by the business management, for next in importance to determining the total number of lines to be provided for comes the question of their distribution.

The number and distribution of lines having been agreed upon, the next step is to determine the number and arrangement of central-office districts, the size and boundaries of these districts, and the size and location of the central-office switchboards.

It is conceivable, although obviously impracticable, that all of the 300,000 lines might be extended to one central office and operated in switchboards there; it is only necessary to state such a proposition to exclude it from further consideration. On the other hand, it is conceivable that a central office might be established in each block; this also is absurd and needs no further consideration. Somewhere between these two extremes must lie the most economical size and number of central offices. The next stage in the problem is to determine this number; to do this no formula, simple or otherwise, is available. The only practicable method is to lay out the territory to be served, in accordance with a number of different arrangements of districts and centers, starting in, say with 10 centers, and extending the study up to as many as 30 or 40, or even more. In the case of all these arrangements there would be certain elements of cost which would not be changed by the different arrangements of central offices assumed. Block wiring and station instruments are examples of these. These elements of cost are omitted from the comparison. All of the items of cost, however, which vary with the different number and arrangement of central offices are computed, all of these being reduced to annual charges.

From these figures, as applied to the various layouts, the number of central offices and the districts which are ideally most economical may be seen. I say ideally most economical for the reason that the practical application of such results requires that a difficult and very complicated adjustment of the existing plant, to conform as nearly as possible to the ideal condition, must be carried out.

While it must appear, even from the brief statement of the steps of the study thus far described, that a vast amount of labor and computation are involved, it by no means represents all that must be done. Before there can be made a comparison of the relative economies of the various groups of offices, a series of studies within studies must be carried out upon many other important elements of the problem.

The first of these is the switchboard study. Before the switchboard study can be made, general methods of operating must be agreed upon; such as the method of handling toll business; whether it shall be done wholly upon a toll board or partly upon a toll board and partly direct from "A" positions; whether it shall be done wholly upon a "two-number" basis or substantially upon a "particular-party" basis. The best method of handling local business must be determined. It must be decided whether the business shall be upon call wires or otherwise; what shall be the capacity of the call wire; what shall be the load which will be assigned to various operators in the system, this in turn being dependent, among other things, upon the character of the service which it is thought necessary to render.

Having agreed upon these and other fundamental data, the question of the best type of switchboard, whether it shall be full multiple or partial multiple, whether it shall be of the transfer type or otherwise, must be settled. The limit, so far as size is concerned, of the multiple board, or any other type which may be considered, must be determined. Also there must be settled a very large number of questions cropping out at every point involving maintenance and operating expenses and methods. All of these factors having been duly weighed, the maximum size and type of switchboard is agreed upon.

The switchboard determinations having been made, the type of cable to be employed must be settled upon. Here again a series of studies is necessary. Of first importance in the cable study is the determination of the standard of transmission which is to be employed, not only for talk between offices within a zone such as Manhattan Island, but also the standard of transmission which it is necessary to maintain between Manhattan Island and the suburbs, and between various points in the suburbs passing through Manhattan and to long-distant points. The importance of this determination will appear when we consider the standard already adopted as the Manhattan standard, which is, assuming the use of the present common-battery apparatus, that the cable employed in Manhattan shall at all times be such that it will give in the worst case a talk as good as could be obtained between two central offices joined by a trunk cable of ten miles of the standard type having the No. 19 gage conductors, with a mutual capacity of 0.07. If this standard were lowered so as to employ the use of No. 22 gage cable instead of No. 19, it would permit the use of a trunk cable costing half as much as that required by the present standard, thus reducing the number of ducts required, and in that way profoundly affecting the results of the study.

In considering the type of cable employed, not only must the standard of transmission be borne in mind, but in determining upon the specifications for the various types of cable needed a long series of special studies is required. These are conducted with a view to determining upon that form of construction in each case which will give the highest standard of transmission, and at the same time preserve the best mechanical conditions needed for hauling in and out of the duct, and also be so constructed electrically and mechanically as to require a minimum of attention from the maintenance point of view. Not only must the various types of cable be carefully fixed upon when considered strictly from the cable point of view, but where suburban and long-distance circuits are to be considered the problem of loading cables presents itself. This involves so much work and study that to give even a brief outline of what it involves would require a paper which itself would extend far beyond the limits of the time allotted for this very general statement of the case.

The general features of the study having been determined upon and the time having arrived to erect a given central office at a center previously located, the question of obtaining the necessary real estate and erecting the central-office building presents itself. In such cases it is usually impossible to obtain the desired property exactly at the ideal center. Practical real-estate conditions must be met and, of the various parcels of property offered, that is chosen which, taking into account all of the circumstances of the case, results in the lowest annual charges. The distance of a given site from the main subways, the character of the neighboring buildings, the price at which the property can be obtained, the possibility of reconstructing the existing building, which may be upon the property, or the necessity of removing it and erecting a new one, and other similar points—all these have to be carefully worked out before a report can be made to the management setting forth the most economical land to purchase.

In other words, before even the land is bought a study must be made of a telephone building which might be erected upon it. Inasmuch as in nearly every case many different properties must be considered, studies for several different buildings must be carried out before the best combination can be determined. After these matters have been decided upon, the details of construction of the building must be further studied. This, as can readily be understood, naturally involves a vast amount of engineering work.

Thus far I have hastily sketched the outlines of a telephone-development study as it is more particularly concerned with the local plant; but as the local plant must be, as time goes on, more and more intimately connected with neighboring plants in the suburbs, and with more distant plants reached by long-distance wires, most careful study must be given to the best methods of establishing proper relations with those plants.

Without attempting to outline in any detail the nature and extent of the work involved in the methods employed in making a suburban toll-line study, and without going at all into the questions of methods of establishing the service to long-distance points, I will say that, considering the broad features of these various classes of conditions, it has been found best, in the particular case which I have taken for my example, to divide the telephone business into three classes—local, suburban, and long-distance.

In determining what shall constitute the local class the engineer finds himself engaged in a problem of great magnitude which primarily concerns the business management, and which is affected by important public and economic considerations as well as by engineering factors and methods. If the local zone is made too extensive it greatly increases the magnitude of the trunk-line plant from which no toll revenue can be derived. This fact reacts upon the rates in such a manner as to make it impossible to give as low a station rate as might otherwise be the case. This tends to restrict the growth of stations, and hence will act as a check upon the growth of the business at large.

The local zones having been determined upon, it must next be decided what shall be the limits of the suburban business, and what shall be classed as long-distance business. Without attempting to explain the various points necessary to be taken into account in determining these questions, I will say that they involve not only those physical factors ordinarily considered to constitute engineering, but that they involve the methods of calling which may be permissible on the part of the subscriber, the entire system of toll rates which may be adopted by the telephone company, the question of whether the subscribers' names and numbers should be listed or not, and other questions of this nature.

* Abstract of a paper presented at the meeting of the American Institute of Electrical Engineers in New York. The author is chief engineer of the New York Telephone Company.

PLAN OF A RADIO-ACTIVE ATOM.—Lord Kelvin elaborates his scheme of positive atoms containing negative "electrions" or electrons inside them, so as to account for the prodigious velocity of these electrons when shot out as they are by radio-active bodies. He supposes that the positive atom attracts the electron with a force varying inversely as the square of the distance. This attraction holds good until the electron begins to enter the substance of the atom, and it then changes into a vigorous repulsion. As the electron works its way in, it has to overcome this repulsion and do a vast amount of work. When it penetrates to within a short distance of the center, the repulsion changes into an attraction, so that when it arrives at the center it is in a condition of stable equilibrium. From this it may be expelled by some shock or strong external force. On entering the region of repulsion, it is shot out with

great velocity, its kinetic energy being equal to the work done in bringing it near the center, provided we can neglect its loss of energy by motions which, while it is in the atom, it gives to the ether in the atom and outside it.—Lord Kelvin, Philosophical Magazine, December, 1905.

[Continued from SUPPLEMENT No. 1581, page 25328.]

RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—III.*

By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

STYLOGRAPHIC PENS AND MANUFACTURE OF GOLD PENS.

IT would appear to be a very simple matter to construct a pen capable of holding a generous supply of ink, especially if one makes it of the stylus form. Nothing perhaps could be more devoid of complications than, say, a glass tube of small diameter, having its one end drawn out to a tapering point, as shown in Fig. 55. This tube may be filled with ink by placing its point in the liquid and exhausting the air in the tube, when the ink will rise up within it, and, if the opening at the point be sufficiently small, the ink will be held by capillarity in the tube. If the point be now drawn along a sheet of paper, a film of ink will be deposited in the shape of lines, or letters and words. Such a pen is frequently used in recording instruments, where a diagram line is produced automatically; but woe betide him who thinks he is in possession of a fountain pen which he can carry in his pocket and use at will. The laws of nature will assert themselves, and it is more than probable that on the first occasion upon which its proud fashioner and possessor takes it from his pocket to show to his envious friends, he will find that it has completely emptied itself of ink. Then he thinks that a cork or stopper fitted into the upper end would prevent a recurrence of such a mishap. It will, to a limited extent, but the warmth of his body—against which the tube lies—is sufficient to expand the air in the tube, and the ink is forced out through the point by this means. Other details are missing, and I have gone with considerable care into the very many patent specifications so as to be able to show how the ingenuity and skill of many inventors during many years have been applied to find the best solution of the problem as to how a stylographic pen should be designed.

Fig. 56 is a drawing of a pen with a rigid point. It is formed of two pieces of wood carefully fitted and fastened together, having a thin tongue of brass placed between them, with the object of supporting a generous supply of ink. The wood is so formed that the points touch each other, and when the pen is charged with ink or liquid color, bold lines, of the same width as the pen, may be drawn. In the example illustrated, the lines would be nearly half an inch wide. It is also possible to use this pen for bold writing, holding it diagonally, as one would use a "J" pen, with the result that German text hand, or similar lettering, could be produced. With such an unprepossessing instrument, very creditable work can be executed.

A pen for a similar purpose is shown in Fig. 57, the operative part being made entirely of metal. It will be seen to consist of a flat plate at the base, while other plates, having their front ends turned downward, are placed in succession above the flat one. At the back they are soldered together, and fixed in a wooden holder. The three intermediate plates have small perforations in them, and these form a means of communication for the ink to pass from one space to the next, as it is wanted. These pens were introduced by Messrs. E. Wolff & Son, who named them the Audascript parcel pens, and I have used them for at least thirty years, in the preparation of bold drawings, for which purpose they are admirably adapted. They are made of various widths, and lines of corresponding widths may be produced by them.

Fig. 58 is a somewhat similar pen, but of a modified design. It bears the name of a French firm.

Fig. 59 is yet another of the same type as No. 57, but for fine work only. This bears the well-known name of Perry & Co.

Fig. 60 appears at first glance to be very similar to the previous examples, but it differs in this respect: The plates at their meeting point are slightly serrated or grooved, in a graduated manner, so that on filling the pen with a rather thick gummy color, the lines produced will have a shaded, or graduated effect, regulated by the depth of the serrations. The pen is Stoakes's patent.

A very simple form of pen, Marsh's patent, although not new, but still marketable, is that shown in Fig. 61. It is a self-filling pen. It consists of a tapering wooden holder, having a small bore hole, extending about an inch from the point, and branching off at a right angle, as shown in the section. The black circle represents an India-rubber ball, fitted on the holder as shown. On immersing the point in ink (having previously squeezed the ball and then released it), the ball becomes charged with ink, and the pen may be used for writing on parcels and the like.

In March, 1809, a patent (3,214) was granted to Messrs. Folsch & Howard for a process enabling the user to produce two or more impressions by one effort in writing. The instrument described is made of glass, enamel, or any sort of stone or metal through which a hole can be drilled. The hole at the point of the pen is very small, but becomes larger a trifling distance therefrom. Common writing ink flowing from the point of the pen will give the first impression; the other copies are obtained by having previously placed alternate sheets of transfer paper, described in the specification, and sheets of thin writing-paper, under that upon which the original writing was being executed. The pressure of the pen, acting as a stylus, reproduced the writing on the writing-paper, as is customary to-day in many places of business. The interesting feature, however, is that here is a fountain pen of the stylographic type described nearly 100 years ago. It is of the simplest possible form, without valves, needle, or other feed devices, simply a tube tapering at one end to a very fine pipette point.

Thomson's patent (12,691) of July, 1849, shown in Fig. 62, consisted of a pen wholly made of glass, in which a piece of capillary tube, *A*, has a bulb, *B*, blown upon it at one end, the extremity of the bulb being drawn off into a curved form suitable for the writing point, *C*, the width of which and the opening therein determine the thickness of the stroke produced by the instrument when in use. The bulb was filled with ink by suction of the mouth, or by other means of exhaustion. The same inventor also shows in Fig. 63 a piston, *K*, fitted to a pen of this description, to be used both for supplying ink to the bulb and also for charging the reservoir. The piston slides in a holder, *A*, and the glass bulb, *B*, having a short

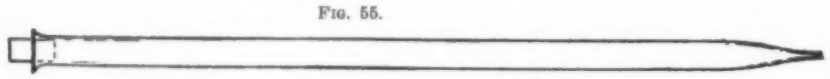


Fig. 55.

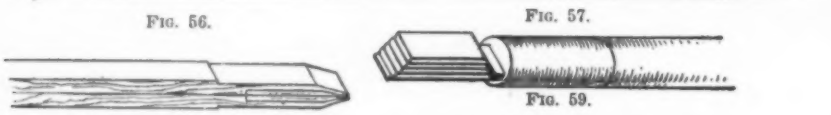


Fig. 56.

Fig. 57.

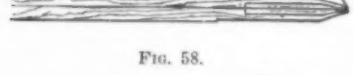


Fig. 58.

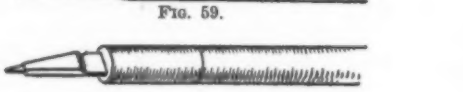


Fig. 59.

Fig. 60.

Fig. 61.

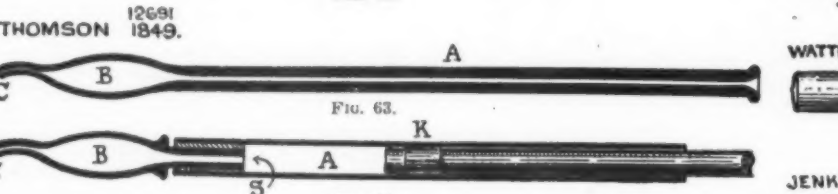


Fig. 62.

THOMSON 12691 1849.
Fig. 63.

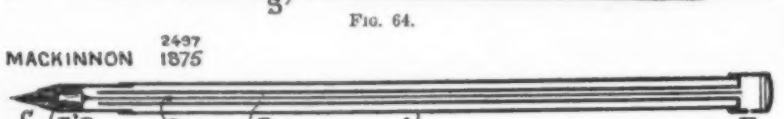
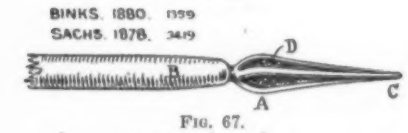
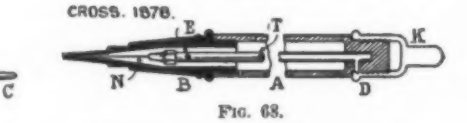


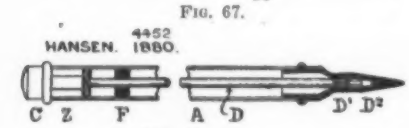
Fig. 64.

MACKINNON 2497 1875
Fig. 65.

Fig. 66.

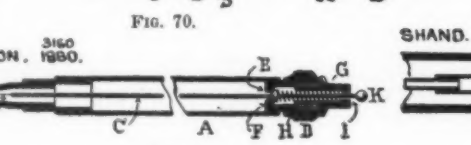

BINKS. 1880. 1939
SACHS. 1878. 3419
Fig. 67.

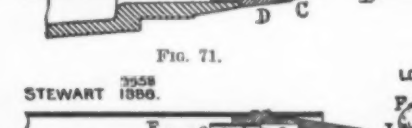

CROSS. 1878.
Fig. 68.


HANSEN. 4452 1880.
Fig. 69.

SOTHERLAND & BROWN. 867 1880.
Fig. 70.

CARTER. 1045 1882.
Fig. 71.


WILSON. 3160 1880.
Fig. 72.


STEWART 3558 1880.

LOUD. 15630 1888.

Fig. 73.

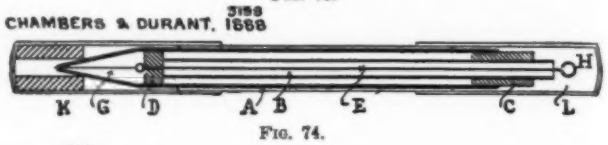

CHAMBERS & DURANT. 3159 1868

Fig. 74.

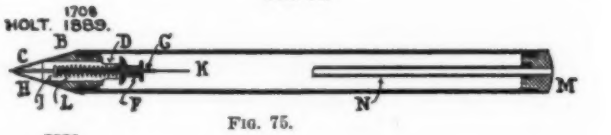

HOLT. 1708 1889.

Fig. 75.

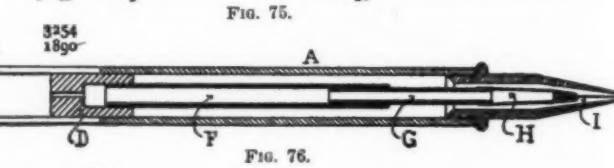

ROBINSON. 3254 1890

Fig. 76.

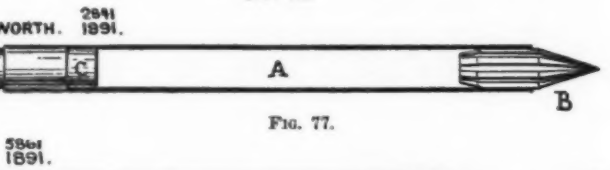

WATTLEWORTH. 2891 1891.

Fig. 77.

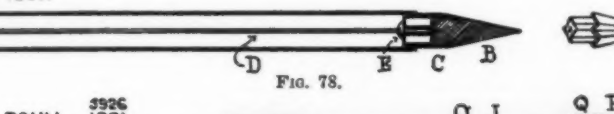

JENKS. 5861 1891.

Fig. 78.

DOULL. 3926 1891.

Fig. 79.

FITZSIMON. 14329 1891.

Fig. 80.

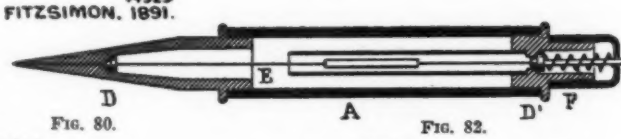

SHAND. 19246 1891.

Fig. 81.

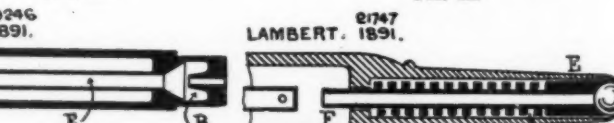

KLERITJ. 21220 1891.

Fig. 82.

LAMBERT. 21747 1891.

Fig. 83.

EVANS. 863 1892.

* Journal of the Society of Arts.

stem, *S*, is fixed into the holder by a suitable packing.

The pen shown in Fig. 64 (2,497, Duncan Mackinnon, July, 1875) consists mainly of a tubular ink reservoir, *A*, closed at its upper end, and terminating in a point holder, *B*, at the other end. The writing point, *C*, may be of glass or any other suitable substance. It is bored centrally with a fine hole slightly tapering downward. A fine wire spindle, *D*, extends the whole length of the pen, its lower end projecting slightly through the bore of the point, *C*, into which it fits almost exactly. The spindle, *D*, carries a weighted valve, *E*, in such a position that it rests on the seat formed to receive it in the point, *C*. Pressure on the point of the spindle when writing will slightly raise the valve, *E*, and allow ink to pass to the paper. A small diameter dip tube, *F*, conveys air from the upper end to the ink reservoir. Air openings are provided in the cap, *K*.

A patent (3,419) was obtained by W. Sachs in 1878, for a style formed of a group of four or five wires bound at one end into a holder, and soldered or otherwise fastened together at the other end to form a point suitable for use as a style. These wires were slightly separated midway between the ends so as to form a cavity capable of holding a considerable quantity of ink.

The pen shown in Fig. 65 is described by the inventor, H. B. Binks, in 1880 (1,359), as being combined with a contrivance for retaining a quantity of liquid ink. It will be seen that it is formed of four wires,

FIG. 84.

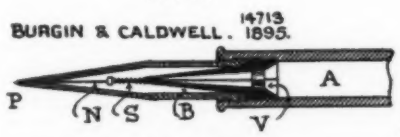


FIG. 85.

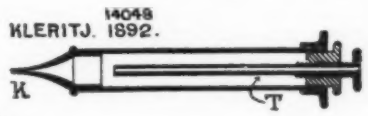


FIG. 86.

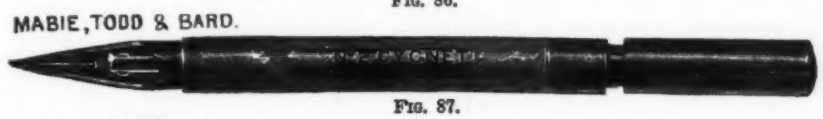


FIG. 87.

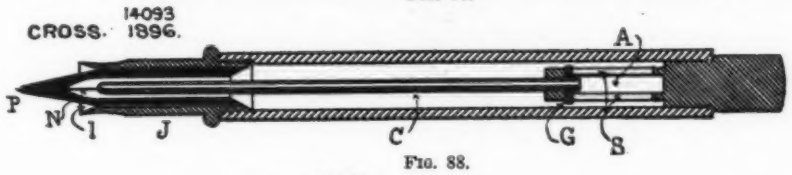


FIG. 88.

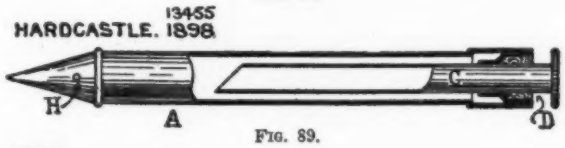


FIG. 89.

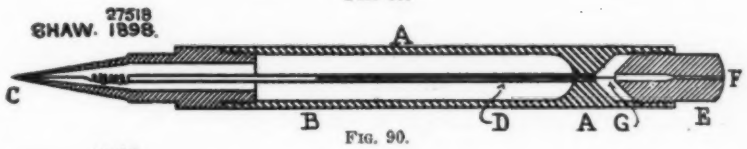


FIG. 90.

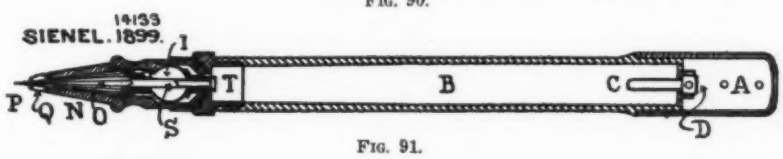


FIG. 91.

A, fixed in a holder, *B*, and soldered together at the other end, *C*, so as to form a writing point suitable for manifold writing or marking. In this respect it is similar to that of Sachs, just described, as patented in 1878. The drawing was made from a specimen in my own possession, and it is shown as having a bunch of fine wires of metal, glass, or asbestos, inserted in the cavity between the main members of the pen or style.

One of the successful pioneers of stylographic pens was A. T. Cross, who obtained patents (3,640 and 4,654) in 1879, in Great Britain. Fig. 66 shows a section taken from one of his stylographic pens in my possession, bearing date 1878, this being probably the year in which his United States patent was applied for. It consists of a tubular reservoir, *A*, into which a point, section *B*, is screwed. The needle, *N*, is attached to the end of a small tube, *T*, extending the greater length of the reservoir. This tube admits air from the upper end, *D*, to a point, *E*, near where the needle is attached to it. The cap, *K*, at the end of the reservoir being partially unscrewed, uncovers the small opening leading to the air tube. The needle is not fixed in a rigid manner, but it is free to slide vertically in the box at the end of the tube. This box also contains a minute spring which tends to keep the needle slightly projected through the point of the pen, thus sealing it and preventing any escape of ink. In the action of writing, pressure of the needle upon paper slightly raises it, and in so doing the ink is permitted to flow. These were among the first stylographic pens of a really practical nature, and were introduced into England by Mr. C. W. Robinson, to whom much credit is due for the popularity of pens of this type. Mr. Robinson claims also to have been the first to suggest the word "stylographic," as applied to these pens, and he says Mr. Cross was the first maker to adopt the name.

In Fig. 67, Hansen's patent (4,452), of November, 1880, a rod, *D*, is attached to the cover, *C*, and passes through the tubular holder, *A*. The rod has an enlarged screwed portion, D^1, which screws into the point section to seal the point, and below this the rod is tapered to form the valve, D^2. To fill the reservoir the rod, *D*, is unscrewed and drawn up by the cover, *C*, and screwed into the socket of the piston, *F*, which piston is packed with rubber or leather. The piston is then used after the manner of a syringe, first placing the point of the pen in ink, which by the action of the piston is drawn up into the holder. The rod is then unscrewed from the piston and pushed forward to the position shown. Sometimes the patentee fitted a washer or plate near the upper end of the reservoir to provide a stop to prevent the withdrawal of the piston, and to form an air chamber, *Z*. An air passage was formed along the rod to the point. Sometimes the rod, *D*, was made hollow in order to provide an air passage.

Fig. 68 shows a section of the stylographic pen of Sutherland & Brown, of February, 1880 (867). Into the reservoir, *A*, is screwed the point section, *E*. An air tube, *S*, fixed at its upper end, passes down the center, and carries the needle or style. The latter consists of a fine wire slightly enlarged as shown at *C*, where it is formed into a valve, and again at *D*, where it becomes of polygonal form, thus acting as a guide and a means of keeping the style steady, and permitting the ink to flow from the reservoir along its flat surface. Above this point it enters the air tube, *B*, freely sliding within it, while a light spring, *S*, tends to keep the valve, *C*, closed. During the operation of writing, pressure on the point raises this valve and permits the passage of ink.

The point of the stylographic pen is a matter that has had considerable attention bestowed upon it. In March, 1882, J. D. Carter (1,045) was granted a patent, and a drawing in his specification is here reproduced in Fig. 69. To render the point more durable he forms it of a jewel, *C*, mounted in a suitable setting, *D*, of gold or other incorrodible metal, the setting being burred at its outer end to secure the jewel therein. The jewel, *C*, is drilled to allow the needle, *B*, to pass through it, and the setting, *D*, is fixed in the holder, *A*, by shrinking the latter around it.

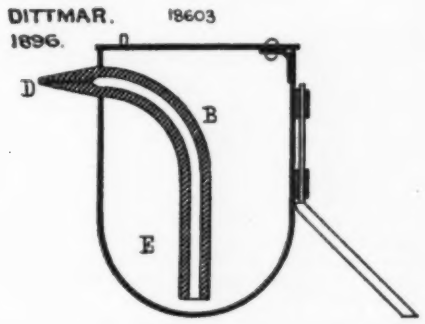
In July, 1880, N. Wilson patented a pen (3,160) shown in Fig. 70, which he called the Wilson stylus, one form of which was made entirely of metal. The construction was very simple. The holder, *A*, forms the reservoir, and into one end of this is firmly fixed the tapered point, *B*. A wire rod, *C*, extends the whole length of the holder, its point reduced in diameter, protruding slightly through the point of the pen. A hollow cap, *D*, is screwed into the other end, or top of the holder, and in this cap is formed an air chamber, *H*, and a vent, *I*, through which the rod, *C*, passes. A valve, *E*, formed on the rod, is forced down upon the diaphragm or valve seat, *F*, by the action of the spring, *G*, until automatically raised by the pressure upon the point of the pen in the act of writing. The rod, *C*, may be moved up and down by hand by means of the knob, *K*, at its upper extremity, for the purpose of clearing the ink duct.

The Livermore pen (see Fig. 99) was introduced into this country in 1880 by Mr. Robinson, to whom I have already referred. The illustration is taken from a descriptive printed sheet which was issued with the pens by the manufacturers. It will be seen that air is admitted by slightly unscrewing the cap, *A*, thus permitting the small opening to be uncovered, and allowing the air to pass down the central tube to the point, *J*, where it escapes into the ink reservoir, *C*. The needle, *G*, is of gold, and is kept in its forward position by a minute gold spring, hidden within the silver spring box, *F*. The writing point is fitted with a tiny tube of platinum set in gold.

In the stylographic pen of M. H. Kerner, for which a patent (5,733) was obtained in December, 1882, the needle is fixed rigidly to the air tube. The air tube is reduced in diameter at the upper end, where it fits tightly in an India-rubber or other elastic washer, fitted in the top of the reservoir. The flexibility of this washer allows sufficient play to the needle in writing. Perforations in the cap admit of the passage of air to the air tube, when the cap is slightly unscrewed, and thence through an opening, to the ink reservoir. An aperture is formed in the screwed portion of the point section to allow of the escape of air from the reservoir as the point section is being replaced after filling the reservoir with ink.

In the penholder of J. Nadal, patented June, 1881 (2,451), the reservoir is fitted with an air tube to which air is admitted by slightly unscrewing the cap,

FIG. 92.



near the bottom of which there is an opening to admit air to the reservoir. The point section screws into the holder, and has an inner concentric sleeve, to maintain the air tube in a central position. This sleeve is formed with channels to allow the passage of the ink to the point section. A rod is fitted with a disk abutting on the end of the air tube, and with a valve, which by means of a spring prevents the passage of ink to the writing point until it is raised by the act of writing.

Mr. Massey-Mainwaring patented a pen in 1885 (8,628), the writing point of which is in the form of a wheel, which rotates in front of the opening from the reservoir, as it is moved along the surface of the paper. This wheel is provided with a circumferential groove, and several radial grooves, which, as the wheel rotates, cause a needle to move up and down, and so produce a constant flow of ink. Such a pen as this must be better adapted for ruling or marking than for writing.

H. Holdsworth, in June, 1885 (7,235), introduced a stylographic pen with a gold point, and a tip of ruby. The needle was made of gold wire, with an iridium tip, and was connected to a spiral spring. The inventor describes the top of the penholder as being loaded in order to prevent it from falling point downward if accidentally dropped.

In the stylographic pen of S. A. de Normanville, who obtained a patent (14,103) for it in November, 1886, the inner reservoir is elastic. It is closed at the upper end, while an ink conducting tube is fitted in the other. The pen or style fits in the tube, and is formed of two half tubes conical at the writing end. A portion is slotted out to give the requisite elasticity and also to admit air.

In Fig. 71 is shown a section of the stylographic pen of W. W. Stewart, who obtained a patent (3,958) in March, of 1888, the chief novelty lying in his method of delivering ink to the writing point. He says that the stylus may be a bristle, looped as here illustrated, and it will be observed that a bristle or horsehair extends from the writing point into the ink reservoir. This bristle is formed into a series of loops in order the more effectually to retain the ink and prevent a too rapid flow.

The instrument shown in Fig. 72 is not intended for use in writing in the ordinary way. In October of 1888 a patent (15,630) was granted to J. J. Loud for

the invention of a marking instrument, specially useful for marking boxes or rough surfaces. The drawing shows that it is provided with a movable spheroidal marking point, *L*, fitting so as to revolve freely in the slightly-contracted mouth, *F*, of the tube, *A*. Above this are a number of anti-friction balls, *K*, held in place by the suitably-formed end of the rod, *G*, pressed into contact with these balls by the spring, *S*. A screwed plug, having an air inlet passing down its center, is screwed firmly down upon the end of the rod, *G*, when the pen is not in use.

Chambers & Durant, in April, 1888 (5,198), obtained a patent for a stylographic pen in which the ink reservoir was made of glass, a substance that would be very suitable for the purpose were it not of so fragile a nature. In Fig. 73 the glass reservoir, *A*, was a tube pointed at one end, and within this tube was a second tube, *B*, supported and kept central by two plugs, *D* and *C*. Passing through the tube, *B*, was a wire, *E*, having a loop, *H*, at one end and carrying a flexible wire, *G*, at the other end. In writing, the end, *G*, projects slightly through the point, and this was capable of adjustment by means of the loop, *H*, and of the wire, *E*. To protect the glass tube from injury it was inclosed in a metal casing, and caps, *K* and *L*, protected the ends.

Holt's specification (1,708) of January, 1889, describes the pen shown in Fig. 74. The style or needle, *K*, is carried in a hollow spindle, *G*, which forms a valve at *H*, in the conical nozzle, *C*. This nozzle is secured to a plug, *B*, which screws into the ink reservoir, and is provided with an extension, *D*, into which screws a plug, *F*, which serves as a guide to the spindle, *G*. A spring, *L*, is placed between *F* and the collar, *I*, to press the valve, *H*, down on its seat. Air is admitted at the upper end through the small tube, *N*, which is screwed into the plug, *M*.

A method of obtaining an elastic needle or stylus is shown in Fig. 75, the invention of the before-mentioned Mr. C. W. Robinson, patent No. 3,254, of 1890. The general arrangement will be familiar, ink being contained in the reservoir, *A*. Air is admitted through the small central tube, *F*, reduced in diameter at *G*, and attached to this is a short piece of flexible rubber tube, *H*, with a plug at its extreme end, into which is fixed the needle or style, *I*. The flexibility of the tube, *H*, allows the needle to rise, and forces it to fall, in the process of writing. The inventor also suggests that in placing the cap, *K*, in position, the India-rubber plug, *D*, becomes compressed and forces air in the ink reservoir, and consequently expels ink at the point.

In Wattleworth's patent (2,841) of February, 1891, we have a pen, shown in Fig. 76, in which the writing point, *B*, is made of a solid block of glass, having external longitudinally-arranged grooves along which the ink flows to its extremity. The inventor proposes that the ink reservoir, *A*, should also be made of glass, and be inclosed in a suitable casing, having a closing plug, *C*, at one end, while the writing point, *B*, is fitted in the other end. A section of the point, *B*, is shown also.

Here in Fig. 77 (5,861) is another pen having a solid point, the idea of T. Jenks, who patented it in April, 1891. The point, *B*, takes the form of a grooved pyramid, and is loosely held in place by a metal collar, *C*, having claws, which permit of a slight vertical movement of the point. A light wire rod, *D*, is screwed into the point, and as the latter rises and falls the rod also does so, at the same time opening and closing the valve, *E*. A nut is provided at *L*, by means of which the valve may be permanently closed, and the point may then be used as an ordinary style without ink.

Fig. 78 shows a pen with a curious internal economy, the invention of D. Doull, whose specification of April, 1891 (5,926), states that the style, *D*, is forced outward by a spring, *S*, the pressure of which is regulated by the thumb-screw, *E*, which actuates a screw-threaded ring, *I*, working in a threaded portion of the reservoir. The nozzle is shown at C^3, and is slit at the corners to give flexibility in writing. The cap is complex, having an inner part, *H*, screwing into the reservoir, and has an India-rubber washer, *L*, to prevent leakage. When the cap is slightly unscrewed, air is admitted through a small hole, *Q*.

Fig. 79 shows the pen of C. P. J. Fitzsimon, patented August, 1891 (14,329). The needle or style, *E*, extends from the writing point, through the upper end of the ink-holder, *A*. Two valves are formed on the needle, as at *D* and D^1, which are forced down upon their respective seats by the spring, *F*, thus normally keeping closed the air passage and also the ink passage from the reservoir to the writing point. The enlargement near the center of the needle is doubtless intended to act as a means of keeping it steady, and also for adjusting the valves.

The next patent (19,246, 1891) shown in Fig. 80, is that of G. E. Shand, who turned his attention to a detail of some importance in connection with stylographic pens, namely, a trap to prevent the escape of any ink finding its way along the air tube. In this invention, patented November, 1891, it will be seen from the section shown, that the pen is formed with an air chamber, *B*, at its upper end, and a short tube forms the continuation of the air inlet. Should any ink find its way into the air tube, *E*, it would continue its course to the air chamber, *B*, and would be prevented from escaping, although air is free to find its way inward.

The specification of December, 1891 (21,220), of L. Kleritj, relates to what he describes as multiple copying implements, useful also as a multiple writer, where fountain pens are used. The drawing, Fig. 81, shows a pen consisting of a tube, *T*, at the lower end of which is a tapering steel point, *U*, having a capillary passage. An opening is made at *V*, for the admission of air. Presumably this opening was covered with the finger in use. No mention is made as to the method of filling the reservoir, and it may perhaps be accomplished by unscrewing the nozzle, or point, *U*.

Fig. 82 (21,747, of 1891) shows a section of E. Lambert's pen, in which a rolling point is used, as in that of Loud. The detail is, however, different, and it is thus described: The writing point consists of a freely-revolving ball, *A*, partly inclosed in the holder, *B*. The ball is kept in place by the bearing, *E*, of the piece, *F*, which is pressed against the spring, *D*. The inventor says that a large-sized instrument may be used for writing on canvas or wood. The ball may be made of vulcanite, or of a metal non-corrodible by ink, and the specification provides for the point containing the ball being in a plane inclined to the longitudinal axis of the pen.

The next pen shown, Fig. 83, the patent of T. Evans of January, 1892 (863), consists of a self-supplying instrument for writing or ruling purposes. As will be seen, the writing point consists of a small wheel or disk, *C*, pivoted at a convenient angle to the extremity of the holder, *A*, which latter is filled with an ink-saturated pad. The edge of the wheel, *C*, is in contact with this, and as the wheel is rotated it picks up enough ink to deliver on the paper. This instrument would probably be more convenient for ruling or drawing lines, than for writing.

In Fig. 84, the patent of Burgin & Caldwell, August, 1895 (14,713), there is not much that has not already been referred to. It relates to a pen in which the flow of ink is controlled by means of a valve, attached to a spring-held needle. The ink-reservoir, *A*, terminates in a conical funnel, *B*, covered by a valve, *V*, attached to the needle, *N*. The free end of the needle projects slightly through the writing point, *P*. When pressed upon paper, the needle is pushed upward against the pressure of the spring, *S*, the valve, *V*, is raised, and ink passes downward to the writing point.

The next pen (14,048, of 1892), illustrated in Fig. 85, is described by the inventor, L. Kleritj, as a "reservoir penholder suitable for so-called multiple writing machines," meaning thereby machines whereby two or more pens are controlled and operated by the movement of a master pen, by which means a corresponding number of writings may be obtained at one and the same time. Several patents have been obtained for instruments of this kind. The pen in this case has a steel cone or point, *K*, with a capillary passage and an internal air tube, *T*. This tube is said to insure uniformity of pressure, and to permit of the adjustment of such pressure.

Messrs. Mabie, Todd & Bard have a stylographic pen which they call the "Cygnet." It is here illustrated in Fig. 86, and it will be seen that the needle action is of simple construction, and perhaps resembles that of the Cross pen more than any other. I have recently examined some of these pens carefully, and find they are as beautifully made as are the celebrated "Swan" pens, of which I shall have something to say later in connection with fountain pens.

Another device of A. T. Cross, patented in June, 1896 (14,093), is here shown in section, in Fig. 87, and in this the needle, *N*, is attached to a rod, *C*, having cross arms or guides, *G*, free to slide in the slots, *S*, in the ink reservoir, *A*. An air inlet, I, is formed between the writing point, *P*, and the point section, *J*.

The drawing (Fig. 88) shows a pen, partly in section, devised by J. Hardcastle, and patented in June, 1898 (13,455). Its principal feature is its self-filling arrangement. The reservoir, *A*, is fitted with a tubular plunger, *C* (or piston as the inventor calls it), open at its inner extremity. This plunger slides through a rubber stuffing-box, *D*. Filling the pen is effected by withdrawing the plunger, ink being thus sucked in through the opening, *H*. It will be evident that this plunger may be pressed home to the position shown after filling the reservoir, thus keeping the pen of a less unwieldy length than if the plunger were to remain in its extreme outward position.

In W. T. Shaw's patent specification of December, 1898 (27,518), the section shown in Fig. 89 is described. The ink reservoir, *B*, has a perforated diaphragm, *A*, in which is fixed the air tube, *D*. A screw plug, *E*, fitted into the end of the holder, is pierced with a small hole, *F*, for the admission of air, and it also carries a fine wire, *G*, which may be used in clearing ink deposits from the nozzle or writing point, *C*. Mr. Shaw considers that this principle may be applied to others of his pens. I would add that Mr. Shaw's name is identified with many other useful inventions connected with writing implements and materials. Having myself been described as a "schemer," I would pass the compliment to Mr. Shaw, whom I consider to be a schemer of no mean order.

The pen shown in Fig. 90 differs in detail from almost all the others referred to, and is the invention of H. Sienel, July, 1899 (14,133). The drawing shows a section of the pen. The writing point, *P*, is secured to a fluted cone, *O*, attached to a rod, *S*, which terminates in a tubular duct, *T*, to convey ink from the barrel, *B*, to the rubber ball, *I*. The conical chamber, *N*, terminates in the ink cavity, *Q*, at the point. Air enters through openings in the cap, *A*, and thence through the valve, *D*, and the tube, *C*, to the ink reservoir, *B*. The patentee states that the use of this pen tends to prevent writer's cramp.

Messrs. Doull & Doull again appear as the inventors of the new pen shown in Fig. 91, which was patented in June, 1900 (11,310). It appears to be somewhat like another pen already referred to, in that the needle, *I*, owes its flexibility to the fact of its being indirectly attached to the flexible rubber tube, *D*. The air tube is held steady by the washer, *F*, through which it passes, and the needle may be adjusted in position, when necessary, by means of the knob, *A*.

The pen shown in Fig. 92 (A. Dittmar, August, 1896, 18,603) is perhaps unique. It consists of a capillary tube, *B*, tapering to a writing point, *D*, and the other end of which dips into the ink reservoir, *E*. I shall not attempt to describe the advantages to be derived from the use of this pen.

Prof. Dittmar, an electrician, collaborated for some time with Mr. C. W. Robinson, endeavoring to coat gold with iridium, with the object of increasing the durability of the needle of stylographic pens—and with a certain measure of success.

A really good stylographic pen is not by any means to be despised. It has special merits of its own, and there are many persons who prefer it to a "nib" pen. If properly constructed it should permit a regular and even flow of ink when in use. To insure this, the ink contained in the barrel should be held in perfect equilibrium, and as the ink is withdrawn in writing, the method of admitting air to take its place should be so beautifully designed that just sufficient air and no more be admitted. Experience has proved that it is best to admit air at the top of the barrel, and by means of properly-constructed passages it should be delivered very near the writing end of the stylograph. The needle should have just sufficient play or freedom to allow it to rise and fall with the greatest ease, neither more nor less. If this be properly adjusted, then the flow of ink is also as it should be.

An all-important matter in the use of pens of any description is the quality and suitability of the ink used. At home in large towns there is no difficulty in obtaining ink suitable for use in stylographic and fountain pens, but travelers abroad, and those who roam, cannot of necessity always procure the right ink just when it is wanted, unless, indeed, they carry a supply with them. It is not the fault of the makers of fountain pens if travelers omit to take this precaution, for suitable ink is offered by the makers, put up in the most convenient form possible. There is, however, an excellent alternative in the form of ink tablets—veritable homœopathic doses of solid ink, one of which is sufficient to charge a pen, the reservoir having been filled with water. These, in my opinion, add one more point, if such be needed, to the convenience afforded to those who carry a fountain or stylographic pen.

(To be continued.)

MOLDING SAND.*

By H. E. FIELD.

A REVIEW of current literature on molding sand brings to my mind an experience some ten years ago. I then pursued a like line of research on the subject of cast iron. The results were as follows: One authority stated that silicon softened cast iron, another that silicon hardened cast iron; one that sulphur was the most injurious element in cast iron, another that sulphur was never present in sufficient quantity to do any harm; one that phosphorus increased shrinkage, another that phosphorus decreased shrinkage; one that manganese hardened cast iron, another that manganese softened cast iron; one that cast iron gained in carbon in passing through a cupola, and another that cast iron lost carbon in passing through a cupola. Since that time all of those apparent contradictions in regard to cast iron have been explained.

A similar contradiction now exists in the literature in reference to molding sand. This is partly due to a confusion in terms and partly to the marked difference of opinion as to what constitutes a molding sand. I shall endeavor to explain away this confusion in terms, but it is not practical to give definite specifications for molding sand, on account of the great variety of work and the different methods of mixing sand for the same work. I wish to make it clear therefore at the beginning of this paper that I am not attempting to lay down a set of standards for the chemical or mechanical analysis of sand. The day for that may come, and when it does the sand question will be much simplified.

If we would improve molding sand or reduce the cost we must have a thorough understanding of what would constitute a model molding sand. We can then intelligently select the materials which nature has placed at our disposal and combine them so as to approach a standard, for I doubt if there is a founder present who can say that he has even come near to perfection in quality and economy in the molding sand which he uses.

We are continually told that the good molding sand of the old days can no longer be obtained and that the present supply is fast disappearing. If this is true it behooves us to gain a knowledge of what is necessary to make up a good molding sand, so that when nature's supply is exhausted we can prepare a satisfactory substitute from her abundant supply of constituent materials. Let us consider the composition of nature's molding sand with this in view.

COMPOSITION OF MOLDING SAND.

Molding sand is made up of two distinct and necessary components: First, silica in the free state, and,

* Paper read before the Pittsburg Foundrymen's Association.

second, silicate of alumina. The free silica gives grain, refractoriness, porosity, and low shrinkage to the sand, while the silicate of alumina furnishes bond. Free silica would be useless without the silicate of alumina, as it would not hold together. Silicate of alumina would be worthless without free silica, as it would not have sufficient porosity and would have too great a shrinkage. A confusion exists in the use of the word "silica" in respect to sand, which I shall endeavor to avoid by designating the silica existing in the free state—quartz silica.

There are several other substances present in all sand. These impurities are not at all desirable and are present from necessity rather than from choice. Quartz silica and clay in correct proportions can constitute a good molding sand without the presence of any other substance.

We will consider the individual characteristics of the constituents which make up a molding sand, for the correct combination of these properties determines the quality and grade of the sand. A knowledge of the effect of the impurities allows us to determine to what extent they may be present in a given sand and still do no harm.

INGREDIENTS OF MOLDING SAND.

Quartz silica, clay, iron oxide, lime and feldspar are the principal ingredients of molding sand.

Quartz Silica.—Pure quartz, or silicon dioxide, consists of 46.67 per cent silicon and 53.33 per cent oxygen. It is very hard, fuses at a high temperature, has no cleavage, and when pure is white. It is, however, generally colored by some oxide of iron. Its fusibility is affected by the amount of impurities present. Quartz is the chief non-shrinkage element in molding sand. It has, however, no bonding properties. The shape of its particles affects the strength of the sand, but they have no strength in themselves, as quartz is absolutely non-plastic. The size of the quartz grains determines the grade of the sand. The percentage best suited for a sand can only be determined by the kind of work for which it is used. The quartz silica should be kept as high as possible, on account of its heat resisting power, its tendency toward porosity and its low shrinkage.

Bond or Clay.—The bond of a molding sand is a clay product. Pure clay or kaolinite is a hydrated silicate of alumina—that is, a silicate of alumina containing water of combination. The exact composition of pure clay is silicon dioxide, or silica, 46.4 per cent; alumina, 39.7 per cent.; water, 13.9 per cent. It is this 13.9 per cent. of combined water which gives the plastic properties to the clay. The bond of a molding sand is not pure clay, but is generally mixed with impurities which weaken its binding power. Clay is formed by the decomposition of feldspars. These are rocks containing silicate of alumina together with silicates of the alkalies. The clay acts as a binder for the sand and holds the refractory quartz silica together. The purity and plasticity of the clay determine the amount necessary to give a sand its correct bonding strength. The clay when pure is very refractory, and it is fallacy to think that because there is a large proportion of bond in a sand it is low in refractory qualities. A high percentage of clay in a sand destroys its porosity and causes high shrinkage and consequently cracks. A sand should be chosen with as low a clay content as is consistent with shop conditions. In foundries where a large percentage of old sand is used it is absolutely necessary to use a new sand containing a high percentage of bond. This is not conducive to the best results. There are, however, certain classes of work the appearance of which must be sacrificed to cheapness of material, and such conditions require that a large amount of old sand be used in the facings. When a lower proportion of old sand is used a new sand with less bond and consequently higher quartz silica will give a more porous facing.

Feldspar.—Feldspars are silicates of alumina combined with silicates of the alkalies. These are generally present in small amounts in molding sand, but they should be kept as low as possible, on account of their fusibility, as they tend to flux the rest of the sand and bind it together.

Oxide of Iron.—Oxide of iron is present in all molding sand, giving it its reddish color. It may be united with the bond as an impurity, or it may form a part of the quartz silica. In either case it lowers the fusing point. The iron comes into the sand either from the original rocks from which the sand was formed or from water containing iron which has trickled through the sand.

Lime.—Lime is sometimes present in molding sand. It makes the sand fusible and liable to crack and crumble in the mold. It may come from the water which has aided in the decomposition of the rocks during the formation of the sand.

ANALYSIS OF MOLDING SAND.

The ultimate analysis of a good molding sand will give results within the following limits:

	Per cent.
Total silica	75 to 85
Alumina	7 to 10
Lime, below	2
Alkalies, below	0.5
Oxide of iron, below	6

The total percentage of iron oxide, lime, and alkalies or the total fluxing agencies should not ordinarily exceed 7 per cent in one sample. In a high grade molding sand used for heavy work they should not exceed 5 to 6 per cent.

A sand analyzed by the rational method should give a quartz silica of from 60 to 70 per cent, a clay substance of from 20 to 30 per cent, with a feldspar below 10 per cent. If the iron were determined separately and subtracted from the clay substance with which it is included by this method we should have a fair indication of the properties of a molding sand, as far as its refractoriness is concerned. The strength is so dependent upon the purity and condition of the clay that it cannot be accurately gaged by any analysis.

Two molding sands, one a so-called strong sand and the other a rather sharp sand, both of which would be classed as a No. 4, give the following results by ultimate and rational analysis:

Sharp Molding Sand.

Ultimate analysis.

	Per cent.
Silica	86.66
Alumina	9.30
Iron oxide	4.53

Rational analysis.

		Per cent.
Quartz silica		67.85
Clay substance	including iron oxide	22.03
	excluding iron oxide	17.50
Feldspar		10.12

Strong Molding Sand.

Ultimate analysis.

	Per cent.
Silica	77.22
Alumina	9.26
Iron oxide	5.56

Rational analysis.

		Per cent.
Quartz silica		64.66
Clay substance	including iron oxide	28.06
	excluding iron oxide	24.50
Feldspar		7.28

REFRACTORINESS.

The impurities which impregnate a molding sand greatly reduce its refractoriness. The sodium and potassium salts in the form of feldspars and mica are constituents of all clays to a greater or less extent and consequently form a part of all molding sands. These alkalies, fusing at a low temperature, may bind the rest of the substances into a hard mass. Iron oxide also increases the fusibility, as does lime, which is occasionally present. This latter is most harmful when present as a carbonate, as a gas would be given off at a high heat which would prove detrimental to the mold. The size of the grain of a sand may affect its refractoriness. Several experts on clays have demonstrated that under certain conditions the fusing point of the clay is determined by the size of the grain. It is probable that this holds good in regard to a molding sand, the larger grained sand having a higher fusing point.

POROSITY.

Some sands are naturally porous, while others are very impervious to gas and moisture. The porosity of a sand determines the amount of venting necessary. Some sands must be vented very freely for all grades of work, while with others the use of a vent rod is hardly necessary. There are four factors which determine porosity: First, the proportion of quartz silica to the bond; second, the size of the quartz silica particles; third, the shape of the quartz silica particles; fourth, the condition of the bond. Generally speaking, the higher the proportion of the quartz silica the greater will be the porosity of the sand. The larger the quartz particles the more porous will the sand be. It will be apparent, however, that the size is limited, from the fact that a sand cannot be too coarse and still give a finish to the casting. The particles should therefore be kept as large as possible and still produce the desired effect as to finish. The porosity is also affected by the shape of the quartz silica particles. Irregular crystalline structures with sharp edges and corners will leave greater spaces between the particles than will regular shaped particles with smooth surfaces, which are apt to fit closely together and thus prevent a free passage of gas or air. The less the proportion of bond used, and still have sufficient binding power in the sand, the greater will be the porosity. It follows therefore that the stronger the bond the less the quantity necessary to produce the same results, consequently the sand having the strongest bond requires the lowest percentage of bond. The tendency of clay to bake together and destroy the porosity of the sand and its tendency to crack, due to excessive shrinkage when drying, render the presence of a large amount of clay bond objectionable. It is very necessary that a sand be chosen with a low percentage of strong bond rather than a large percentage of weak bond.

STRENGTH.

The strength of a molding sand determines its adaptability for different kinds of work. Some castings may be made with sand having comparatively little strength, while for others a strong sand is absolutely necessary. The amount of strength necessary is somewhat dependent upon shop practice. The methods of molding, running, venting, and mixing of the sand must all be considered in determining the proper strength of a sand for a given class of work. The practice of using flour, molasses or clay wash in mixing up facing, together with the proportion of coal dust and old sand used, is also an important factor to be considered in the choice of a sand. In foundries where nailing is generally resorted to, a weaker sand may be used than where nails are not used. A good mechanical mixer which intimately surrounds each particle of old sand with particles of new sand, rather than putting the old and new sand together in chunks, also permits the use of a sharper sand. Where flour or molasses is used or where the proportion of old sand to new sand is comparatively small, the use of a sharp sand is possible.

The strength of a sand depends upon three conditions: First, the proportion of bond; second, the strength of the bond, and, third, the shape of the quartz silica particles.

SIZE OF GRAIN.

The grade of a molding sand is determined by its grain. The finer grained sands are used for the lighter work. Sands are graded and sold by numbers, based upon the size of the grain.

A sand should be as fine grained as possible and still satisfactorily fill the other requirements of a molding sand. This is due to the fact that the finer grained sand will give a better surface to the casting. The grain of the sand is determined largely by the grain of the original rock from which the sand was formed. The fineness of the sand is obtained quantitatively by the use of a series of sieves. Of these, 100, 80, 60, 40 and 20 mesh are used. A weighed amount of the dried sand is placed in the 100-mesh sieve, which is shaken for a definite time, say, one minute. The siftings are carefully weighed and the weight recorded. The 80, 60, 40 and 20 mesh sieves are used in the same way. These separate weighings are multiplied by the number of the mesh of the sieve. There is a certain loss due to dust flying, etc., which is found by subtracting the total of the weights obtained from the original weight. This loss is multiplied by the average mesh of the sieves, which is 60. The sum of the products of the weights obtained by the number of the sieves divided by 100 constitutes what is known as the degree of fineness of the sand. This method is quite unsatisfactory in many ways, as all sands of the same degree of fineness do not have the same physical effects when used as a molding sand. This is due to the fact that the proportion of sand which passes through each sieve has an important bearing upon the quality of the sand. A sand whose particles are all small but of uniform size will give better results than one with a combination of large and small grains which might be of the same degree of fineness when judged by the standard sieves.

It is never advisable to judge of the fineness of a sand by its appearance, for a comparatively few large particles will give the whole sand the appearance of being coarse, while in reality it may be very fine when judged by the standard sieves.

CONCLUSION.

We have looked at molding sand from two viewpoints: First, as a study of the materials which go to make up a molding sand, and, second, as a study of the properties which are necessary and most desirable in a molding sand. A thorough understanding of the principles considered should aid us in intelligently selecting the best sand for our individual use.

Let me remind you that what proves to be a good sand in one foundry may prove just the opposite under the differing conditions of another. It is with this fact strongly in mind that I give you general information rather than specific data which might apply to one set of conditions. Any future improvement in the quality of molding sand will come from an intelligent interpretation of the principles which we have studied to-night.

[Continued from SUPPLEMENT No. 1581, page 25334.]

LIGHTNING AND THE ELECTRICITY OF THE AIR.—II.*

By ALEXANDER G. MCADIE.

SOME MEASUREMENTS OF THE POTENTIAL OF THE AIR.

EXPERIMENTS at the Smithsonian Institution.—In 1886 some investigations on atmospheric potential were undertaken at Washington, under the direction of General Hazen, Chief Signal Officer, and more immediately under the supervision of Prof. Mendenhall. Experiments were made by the writer at the tower of the Smithsonian Institution. The electrical history of a summer afternoon thunderstorm may be read in the following record of the potential changes. June 14, 1886; a showery and oppressive morning; the wind very light and coming in feeble puffs; southwest at 11:30 A. M. (See next page.)

Experiments at the Top of the Washington Monument.—The electrical history of a thunder storm as indicated by an electrometer at the top of the monument is very interesting. The following is a description of one of many experiments thus made:

May 6, 1887. We are 500 feet above the city streets. It is a warm afternoon and looking from the west windows of the monument one sees through the near haze around Arlington and Virginia hills far to the southwest a patch of dark cloud. It needs little experience to presage a thunder squall. It is about twenty miles away and will reach us in about forty minutes, perhaps in less time. At ten minutes to three o'clock the clouds are overhead, and this is the last we shall see of the world outside until the storm is over, for it is necessary that the heavy marble doors be swung to. All is dark in the monument save for the beam of reflected light traveling along the ground glass scale. The little mirror reflecting the light is attached to the electrometer needle, and in this way the most minute movement of the needle is made known. From the south window the nozzle of

* Reprinted from Journal of Electricity, Power and Gas.

the water-dropping collector protrudes through a small opening. The wind rises, and we notice the needle moving steadily toward the point marked 1,000 volts, positive. This means that the pull upon the air is steadily increasing. Suddenly the needle flies to the other side of the scale and we know that the air, like a piece of over-stretched rubber, has snapped and given way under the strain. The pull is now negative, i. e., in an opposite direction, and now the needle dances and we hear outside the rumble of distant thunder, all indicating the approach of the disturbance. Nearer comes the storm, if we may judge from the rapid fluctuations of the needle. Values of 3,000 and 4,000 volts are common.* The deflections are at times greater than the scale limits. With every flash of lightning we catch the fleeting reflection of a little spark in the electrometer. On one occasion running a wire from the ironwork to within a small distance of the collector we counted more than 100 ⅛-inch sparks in a minute. If we place the eye close, but not too close, to the little peep-hole through which the nozzle goes, we shall see the stream of water twisting and breaking into spray, and each time it lightens, becoming normal quick as the flash itself, but only to rapidly twist and again distort itself.

Increase of Potential with Elevation.—Some idea of the normal rate of increase of potential with elevation can be gained from the following table:

TIME, A DAY IN NOVEMBER. THE TWO STATIONS ABOUT 500 FEET AND 45 FEET, RESPECTIVELY.

Time. P. M.	Monument. Volts.	Signal Office. Volts.	Difference. Volts.
1:30	900	216	684
1:32	888	246	642
1:34	900	216	684
1:36	862	246	616
1:38	875	240	635
1:40	825	222	603

THE ELECTRICITY OF THE UPPER AIR AS MANIFESTED IN AURORAL DISPLAYS.

One of the great mysteries of the upper air is the aurora. No paper treating of the electrification of the atmosphere can be complete without a more or less imperfect knowledge of this most beautiful of all electric displays. The following brief review is from an article published in the Century Magazine for October, 1897, somewhat modified to suit the requirements of the present publication:

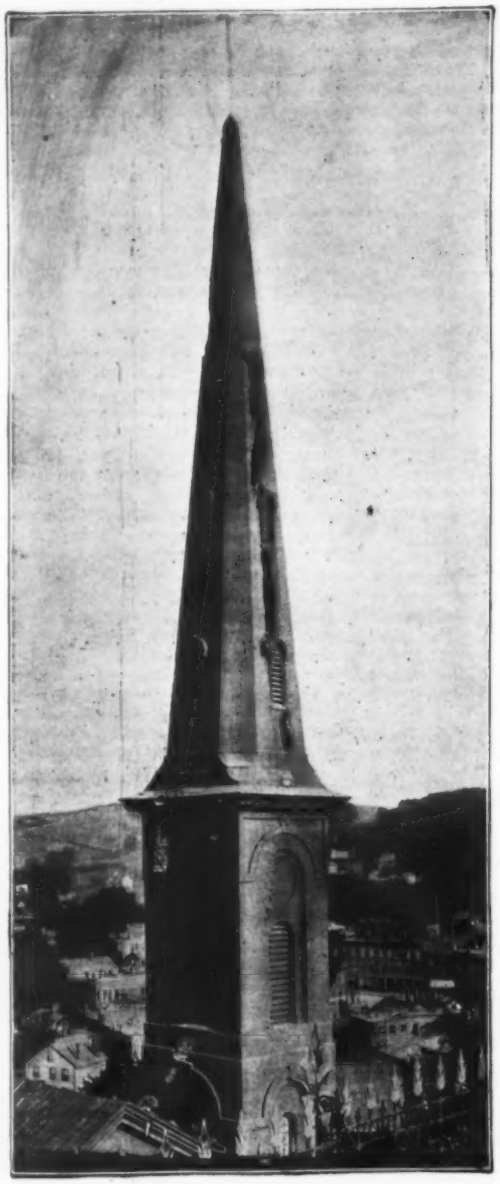
WHAT IS AN AURORA?

On the first day of January, 1892, Dr. Brendel and Herr Raschen reached the Alton Fiord, Lapland, to remain several months, studying the auroral displays and magnetic disturbances. Brendel succeeded in photographing the aurora, a very difficult thing to do, as all who have attempted it know. The deep reds, which are so beautiful to the eye, make little impression on the photographer's plate, and the light itself is generally feeble and flickering. Not unaptly have the quivering auroral beams been called "merry dancers." Even the bright displays are hard to photograph, as we may see from an entry in Gen. Greely's notebook on January 21, 1882: "A most beautiful aurora," he says, "with intense light, at times sufficiently bright to cast my shadow on the snow. Rice exposed a sensitive plate without effect, but the constantly-changing position of the aurora may have been the cause."

Once the sun-spot period was clearly established, it was only necessary to ransack chronological lists of auroras to find how intimately auroras and sun spots were connected. Three patient investigators, Wolf, Fritz, and Loomis, soon proved that auroras were most frequent when sun spots were most numerous.

* At the Eiffel Tower values as high as 10,000 volts have been obtained.

The next step was to find individual relations. One bright September morning thirty-seven years ago, Carrington and Hodgson, separately studying the face of the sun, saw a remarkable outburst near the edge of a great spot. For some days the magnetometers at



PHOTOGRAPH OF BROADWAY CHURCH,* NORWICH, CONN., DAMAGED BY LIGHTNING JULY 29, 1894, 1:30 P. M.

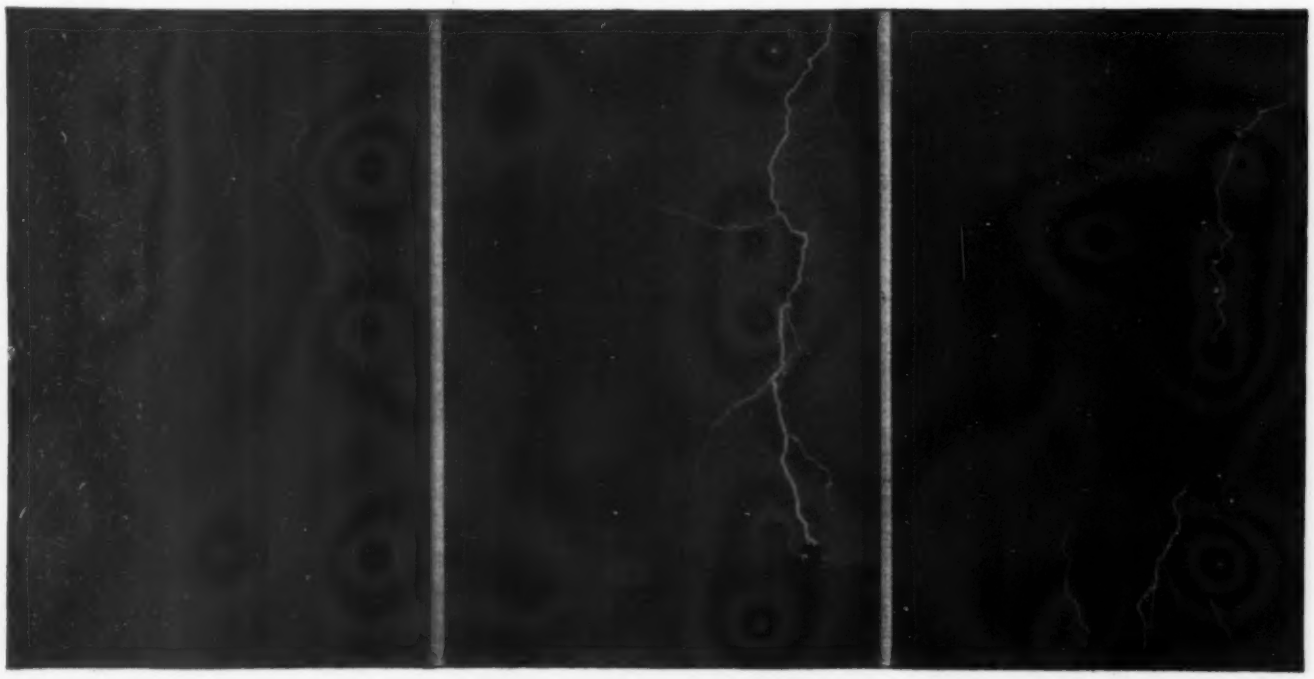
Photographed by Mr. F. J. Moulton.

Kew showed unusual perturbation, and for several nights magnificent auroral displays were seen over

* The spire is of brick, 198 feet high, with a cap of brownstone. It was not protected by a lightning rod. See SCIENTIFIC AMERICAN, September 8, 1894.

Time.	Volts. +	Volts. −	Remarks.
11:30 A. M.	78	.....	
35	54	.....	
40	60	.....	Wind southwest, light.
45	36	.....	
50	54	.....	
55	54	.....	
58	78	.....	
12:40 P. M.	66	.....	
45	72	.....	
50	3	.....	
52	.....	66	
55	.....	138	Wind from south-by-east, puffs, no particular cloud conditions.
57	.....	168	
1:00	.....	210	
02	.....	90	Very light rain began at 1:02 P. M.
12	.....	42	
05	120	.....	
07	198	.....	
09	216	.....	Distant thunder at 1:09. Clouds in west looking like advance guard of thunderstorm, with some blue sky, however.
10	210	.....	
11	198	.....	
12	186	.....	
13	156	.....	
14	132	.....	Thunder at 1:13:25. Clouds also in northwest. Thunder from 1:16:20 to 1:17:40.
15	108	.....	Rain commenced at 1:17; lasted five seconds.
16	108	.....	
17	96	.....	
18	96	.....	
19	78	.....	
20	72	.....	Rain commenced 1:20:15; light. Ended 1:22.
21	54	.....	
21-22	54-72	.....	Thunder at 1:22:20.
22	54	.....	
23	30	.....	
24	30	.....	
25	30	.....	
26	12	.....	
27	6	.....	Very light rain commenced 1:27:30.
28	.....	12	
29	.....	54	
30	.....	78	
32	.....	192	Very distant thunder.
33	.....	246	
34	.....	240	
35	.....	252	
38	.....	234	
39	.....	180	Light rain.
40	.....	174	Rain ended 1:39:20.
1:43 P. M.	.....	150	
44	.....	120	
45	.....	72	
48	.....	24	
50	12	.....	
55	66	.....	
58	78	.....	
2:00	78	.....	
01	78	.....	Rain commenced 2:01 P. M.
05	78	.....	
09	90	.....	
10	90	.....	
13	72	.....	A very heavy cumulus cloud is moving up toward the place of observation from the river.
15	84	.....	
17	96	.....	
20	90	.....	
21	66	.....	
23	72	.....	
25	66	.....	
30	48	.....	
35	48	.....	
40	54	.....	
45	30	.....	
50	30	.....	
55	24	.....	
57	0.0	.....	
58	.....	120	Bright and shining; large, white cumulus clouds in southwest, southeast and east, but the northwestern horizon is black and evidently a storm is coming.
3:00	.....	114.00	
02	.....	150	
03	.....	186	First thunder 3:03:15 to 3:03:40; thunder 3:07:30 to 3:07:42; calm; thunder 3:09:10 to 3:09:13.
04	.....	228	
05	.....	276 / 288	
06	.....	300	
07	.....	312	
08	.....	.....	
09	.....	348	Thunder 3:10:08 to 3:10:10.
10	.....	360	
11	.....	390	
12	.....	396	Thunder 3:12:25 to 3:12:27.
13	.....	420	
14	.....	444	
15	.....	438	Thunder 3:15:30 to 3:15:32.
16	.....	444	
18	.....	480 / 504	Thunder 3:17:30.

two continents. It was long thought that a violent magnetic disturbance occurred *simultaneously* with the outburst, but recent examination of the records disproves this. In 1872 Prof. Young noticed a disturbance in the chromosphere in the neighborhood of



MULTIPLE FLASH.

From Popular Science Monthly, 1898, McAdie.

DESTRUCTIVE FLASH.

From photograph by McAdie.

CLOUD AND MULTIPLE FLASH.

From photograph by McAdie.

a sun spot, and upon asking the astronomers at Greenwich and Stonyhurst to examine their magnetic records, it was found that great disturbances had occurred about that time. Ten years later the astronomer at Greenwich sent out a message that read something like this: "Remarkable sun spot now visible. . . . Area of whole spot, 247/100,000 of the sun's visible surface." Try to imagine what this means, and fancy yourself on the sun while that tremendous storm was in progress. We know that here on earth there was a magnetic storm with auroral displays that beggars description. Beginning a little before daylight on November 17, 1882, not a wire of the Western Union Telegraph Company could be used for three hours. The market quotations could not be sent. Late in the afternoon the trouble seemed to decrease, but at night there was a brilliant auroral display, and all telegraphic service was again interrupted. A very short circuit from Boston to Dedham showed the disturbance equally with other circuits. The cables to Europe and the wires to Chicago were alike unworkable. A message was sent from Bangor to North Sidney, 700 miles, by cutting out the regular batteries and allowing the energy of nature to have its own way. The current was just as strong as if a hundred cells had been at work. At Albany the switchboard was ignited; and in telephone offices generally the annunciators dropped continually. Switchboards and wires were burned at Chicago. Incandescent lamps were illuminated in St. Paul, and even in far San Francisco the telephone operators were nigh distracted. Over half of North America, across the Atlantic, and on over northern Europe it seemed as if legions of ethereal demons were busy inciting electric and magnetic apparatus to strange and mischievous antics.

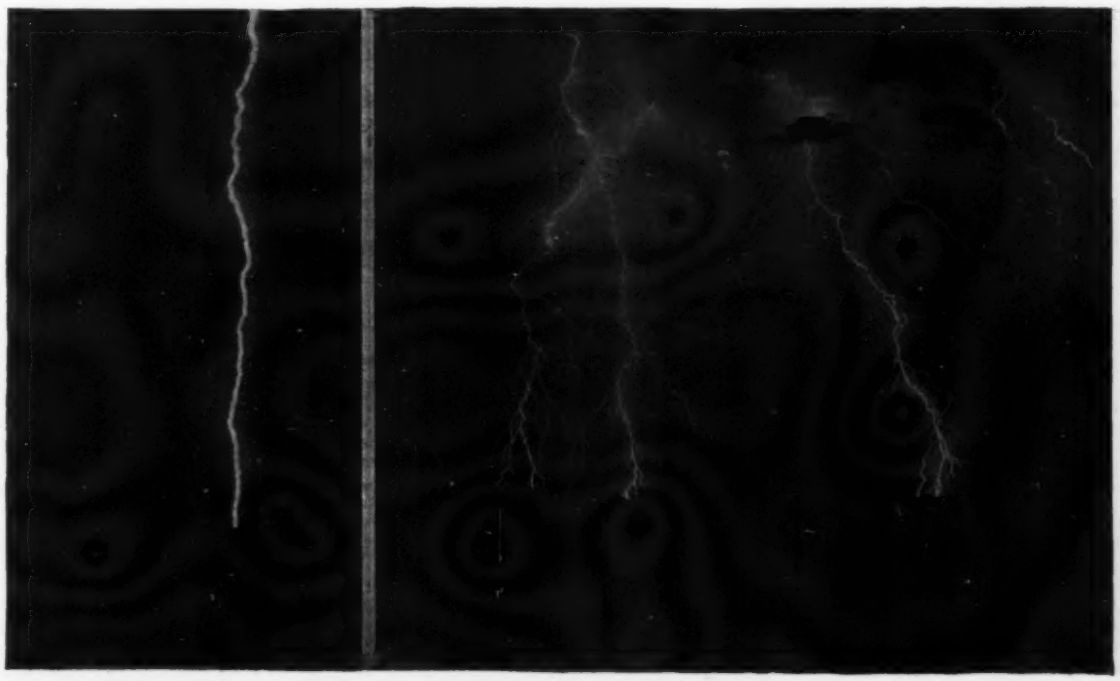
It so happened that about the pole that year were clustered representatives from twelve nations. The Russian international expeditions were at the Lena Delta and Nova Zembla; the Norwegian at Bossekop; the Dutch at Dicksonhavn; the German at Kingua Fiord; the Finnish at Sodankyla; the Swedish at Spitzbergen; the Danish at Godthaab; the Austro-Hungarian at Jan Mayen; and the British at Fort Lee. France had two stations in the Antarctic region, and our own country had the well-known Lady Franklin Bay party under Greely, and the Point Barrow party under Ray.

November 14-19, 1882, was a period never to be forgotten by these Arctic prisoners. While we at home saw the display of a decade, the observers of the frozen North, turning their eyes southward or westward or eastward, saw visions glorious by *day* as well as by night, and felt perhaps some measure of recompense for their isolation and peril. Coming out of their dark quarters, they were startled and at first blinded, and Gen. Greely writes: "The curtain appeared at one time so near our heads that Gardner and Israel speak of having unconsciously dodged to avoid it." In Ralston's diary is the entry: "The aurora appeared so low down that I raised my hand instinctively, expecting to bathe it in the light"; and Brainard relates a like impression. What a pity that under such conditions no electrometric apparatus was available! With Thomson water-dropping collectors and multiple-quadrant electrometers, records of the electrification of the lower air could have been obtained, and a few more threads raveled out from nature's tangled skein. Some observations of the potential of the air, made by Andree, who was a member of the Swedish party at Cape Thordsen, Spitzbergen, seem to show that the electrical potential diminished very rapidly during an aurora, and in fact became negative. As is well known, this same Andree has lately attempted to reach the pole in an airship. Not the least valuable result of the adventure will be the increase in our knowledge of the electricity of the air in polar regions. We shall learn a little more about the height of auroras. We know now that while they are from fifty to seventy miles high in latitude 50 deg., the height decreases as we approach 68 deg. At Godthaab, Paulsen measured many with theodolites, and found that some were less than two-fifths of a mile high. Hildebrandsson and others have seen auroras below the clouds. Such results lead us to believe that the time is ripe to suggest a new classification of auroral displays. It has been further noticed that the colorless and quiescent auroras were *not* necessarily coincident with magnetic disturbances, while those of brilliant color and rapid change were. Many so-called auroras are probably what the Germans would call *Wetterleuchten*, and akin to silent lightning.

Our little planet unquestionably responds to solar disturbances. The intense auroral displays that occur simultaneously over continents are, one may think, answering signals to the messages flashed from the sun through the quivering ether. But we may also have our own little storms and disturbances; and while appearances may be similar, the phenomena are of different origin. Some of the difficulties and discrepancies which have been met in tabulating sun-spot, magnetic, and auroral phenomena can be thus explained. One wise remark by Prof. Young should not pass unnoticed. "The solar tumult," he says, "may be the brother, and not the father, of our aurora." But this much is plain: The phenomena are closely allied, and mastery of the terrestrial displays will enable us to reach out and attempt the conquest of the solar ones. It may be frankly said that the man of

CHIMNEY, STRUCK JULY 29, 1890.

From Elec. Zeits., Greibel.



IMPULSIVE RUSH AND SO-CALLED DARK FLASHES.

From Popular Science Monthly, McAdie.

MULTIPLE FLASH.

From Scribner's Magazine, A. Binden.

science feels that the aurora has baffled his scrutiny.

PROTECTION FROM LIGHTNING.*

At the Aberdeen meeting of the British Association for the Advancement of Science, Sir William Thomson made the remark, "If I urge Glasgow manufacturers to put up lightning rods, they say it is cheaper to insure than to do so."

This was the answer given by practical business men, concerned only with questions of profit and loss, to the foremost physicist of our time; and their answer will serve as fairly representing views widely held, founded upon the double belief that the risk from lightning is not so very great and the protection afforded by the present methods not sufficiently certain to warrant implicit confidence, and justify the necessary expense.

The recent remarkable experiments of Dr. Oliver Lodge, in his lectures before the Society of Arts, opposing and to some degree directly contradicting the empirical rules of the Lightning Rod Conference, have given support to the belief that the protection was uncertain. Indeed, realizing that his work might be misinterpreted, Lodge has stated: "An idea at one time got abroad that my experiments proved existing lightning conductors to be useless or dangerous; this is an entire misrepresentation. Almost any conductor is probably better than none, but few or no conductors are absolute and complete safeguards. Certain habits of lightning rod practice may be improved and the curious freaks or vagaries of lightning strokes in protected buildings are intelligible without any blame attaching to the conductor; but this is very different from the contention that lightning rods are unnecessary and useless. They are essential to anything like security."†

What Lodge's brilliant experimental work does show is that the momentum of an electric current can not be overlooked in a lightning discharge. The old "drain-pipe" idea of conveying electricity gently from cloud to earth must give place to the new proposition, based upon recent discoveries, that even draining off must be done in an appropriate way to be effective. To illustrate, the rocks and trees upon a mountain side may influence and determine the course of a mountain stream, but even a good-sized channel would not suffice to carry off safely an avalanche, or control the path of a landslide; so with lightning. In the last four years we have learned, through the work of Hertz and others, that when an electric current flows steadily in one direction in a cylindrical wire its intensity is the same in all parts of the wire; but if the current be of an oscillatory character, i. e., a current which rapidly reverses its direction, the condition no longer holds, and if the alternations are very rapid the interior of the wire may be almost free from current. If lightning then be a discharge of an oscillatory character, it may happen that the current down the lightning rod would be only *skin deep*. The experiments of Tesla and Elihu Thomson with currents of great frequency of alternation and very high potentials open the door to systematic study of discharges such as the ordinary lightning flash. In daily work currents of this type are coming more and more into prominence, and the time is not far distant when the lightning flash will be studied as an electrical discharge of this character. Protection entirely adequate for such discharges will then be forthcoming. Indeed, the reasons why present methods occasionally fail are now understood, and the proper remedies apparent.

LIGHTNING CONDUCTORS.

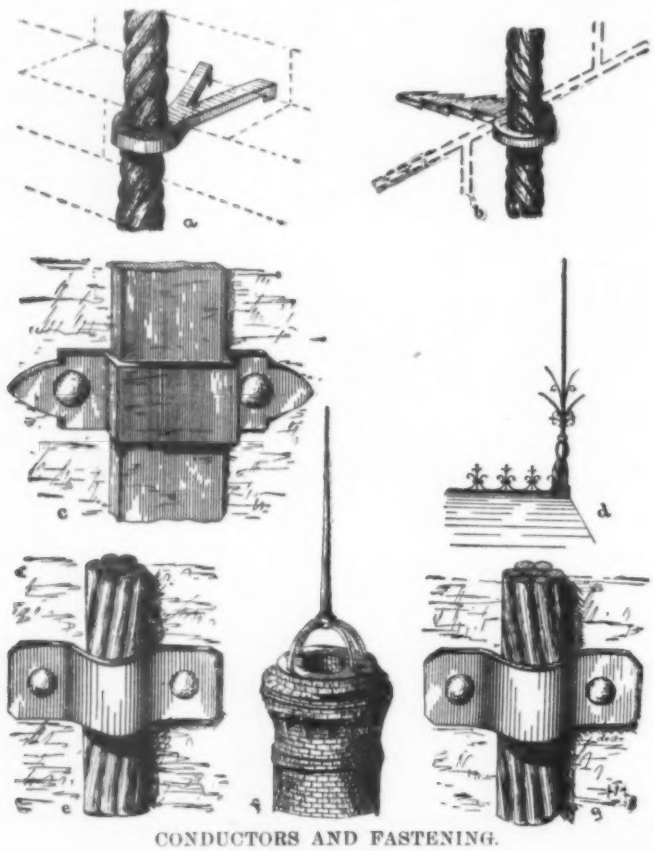
Beyond doubt Franklin proved his case that lightning rods were efficacious in the protection of buildings. Buildings with conductors when struck by lightning suffered little damage compared with those without protectors.

Effect of the Action of Lightning Upon a Rod.

The chief defects likely to occur are blunted points and breaks in the continuity of the connection. The function of a lightning rod is two-fold; first, that of conducting the charge to earth, and second, the prevention of a disruptive discharge by silent neutralization of the cloud electrification. The latter explains why a rod terminates in a point, and likewise why points in good connection with the ground are always *desirable* upon buildings. Indeed, points are somewhat like small water pipes connected with a large reservoir. If you have enough of them and a sufficient time you may drain the largest reservoir. Furthermore, when some sudden rise or flood occurs in the reservoir, these minute drains may be of service in keeping the height of the water down.

In the case of lightning the points are the small escape pipes, the layer of air between cloud and earth the retaining wall, and the cloud electrification—or charge—the overflowing or destructive element. A large conductor, be it rod or tape, on the other hand, is more like a large main or waterway, which has its gate shut until the flood is imminent. Then the gate is suddenly opened and we try to compel the torrent to keep to the provided path. We trust in its ability to safely hold the flood. Generally it does. In perhaps nine cases out of ten, the lightning conductor, if it be such a one as we will describe later, does carry the flash to the earth; but there are cases where the discharges have been heavy and overflows have resulted. To carry the lightning flash "the lightning conductor should offer a line of discharge more nearly perfect and more accessible than any other offered by the materials or contents of the edifice we wish to protect." To prevent the discharge "the conductor should be surrounded by points." These quotations are from the Report of the Lightning Rod Conference.

The statement that lightning always follows the path of least resistance, as commonly understood and stated, needs modification. True it is, that when the air is strained by being subjected to the electrifications of cloud and earth, the weakest spot gives way first, and this is apt to be in line with some small elevated knob or surface; but it is equally true, and is perhaps the more general case, that when a really vigorous disruptive discharge does occur, it is somewhat, as Dr. Lodge aptly puts it, like an "avalanche." As a matter of fact, we find from the study of actual cases where buildings have been struck, that lightning often disregards metallic surfaces and points. What we should first know is, whether the condition is to be one of "steady strain,"* or "impulsive rush"* discharge. In the case of "steady strain," the metal is apt to influence the path of discharge; in the case of an "impulsive rush" discharge, even *points* seem to lose their efficiency and become of little use.



CONDUCTORS AND FASTENING.

From Anderson, and Lightning Rod Conference.

In a letter‡ of an old British admiral there occurs a description of his being called upon to approve some specifications for a lightning conductor to be erected on a certain lighthouse. He was himself a believer in the "surface" theory of Harris; but thought that, to make sure, he would go and consult his friend Faraday. Faraday, who saw only the question of conductivity in the problem, said very positively that the solid rod was better than the tube (which gives greater surface with less copper), and that *solid volume was everything*, superficial area nothing. Moreover, if Harris says otherwise, "then he knows nothing whatever about it." The admiral straightway approved the solid rod conductor for the lighthouse. Within two or three days he met Harris, and bringing up the question was told by Harris, "*Surface* area is most important, and if Faraday says otherwise, then he knows nothing whatever about it."

Up to a certain point Faraday was right; a copper rod an inch thick is capable of carrying almost any flash of lightning, and is undoubtedly a great protector, but if, as we have reason to believe, the core is seldom given a chance to carry the current, why have it? The views of Sir W. Snow Harris, based as they were upon close study of many thousand cases of lightning action, are finding in the experiments of to-day the confirmation so long needed.

While not going into details regarding this question of the shape of the rod, let us emphasize the fact, so recently brought out, that if an electric current flows steadily in one direction in a cylindrical wire, as shown by Hertz, but that with a current of an oscillatory character, i. e., a current which rapidly reverses its direction, this condition no longer holds, and if the direction is altered very rapidly, the interior of the wire, in our case the lightning rod, may be almost free from current.

In 1882 appeared the report of the Lightning Rod Conference, in many respects the most important contribution to the literature of the subject yet made. While so many foreign governments, and in particular France, had by means of officially constituted boards taken a governmental interest in the protection of the people from the dangers of lightning, the English speaking people of the world, aside from the few directions officially issued for the protection of magazines and lighthouses, remained without any authoritative utterance upon the subject; and while this conference itself did not have strictly official sanction, it carries, from the character of its makeup, a weight certainly as great, if not greater, than an official board. It was simply a joint committee of representative members of the Institute of British Architects, the Physical Society, the Society of Telegraph Engineers and Electricians, the Meteorological Society, and two co-opted members. As might be anticipated from such auspices, the report is an excellent one, and must stand for years as the embodiment of the most widely gathered information and well considered decisions. The report is emphatically one based upon *experience*.

The famous free-for-all discussion which occurred at the British Association meeting in 1888, so far as our judgment goes, simply proved that the decisions of the conference could not at present be disregarded. As the president of the meeting, Sir William Thomson, said, "We have very strong reason to feel that there is a very comfortable degree of security, if not absolute safety, given to us by lightning conductors made according to the present and orthodox rules." There are one or two further features to which attention may be called. There are some very prevalent misapprehensions with regard to lightning—for example, that it never strikes twice in the same place; that the most exposed place is always struck; that a few inches of glass or a few feet of air will serve as a competent insulator to bar the progress of a flash that has forced its way through a thousand feet of air, etc. These are alluded to in the following general directions.

(To be continued.)

CELLULOID AND GALALITH.‡

THE comparative study of both substances is interesting, both on account of the similarity of their properties and the resulting applications, and their preparation and chemical composition, which are quite different. These two organic substances, prepared artificially, are employed in the manufacture of toys and objects imitating horn, amber, ivory, coral, malachite, and ebony.

Celluloid plays an important rôle in photography, in which it has become indispensable in the form of films. This chemical product, a solution of nitrocellulose in camphor, was first prepared by the brothers Hyatt in 1869 at Newark in the United States. Galalith, more interesting since it is a newer product, made its appearance but a short time ago. The name was adopted by the manufacturers, the Vereinigte Gummiwaren-Fabriken, of Harburg and Vienna, and may be translated as "milk-stone," though the form of the word is slightly irregular and really should be "galalactolith." It is derived from milk, but not as some periodicals have asserted, from petrified milk.

* From Bulletin No. 15, U. S. Weather Bureau.

† Page vi, "Lightning Conductors and Lightning Guards."

* Terms used by Prof. Lodge.

† See report of Lightning Rod Conference.

‡ From the French of M. R. Coulon in the Revue de Chimie Industrielle.

Two obstacles have been met with in the manufacture of celluloid—the camphor odor and the inflammability. Numerous products have been proposed to replace the expensive camphor, as for instance, the artificial camphor prepared from pinene chlorohydrate, but the celluloid thus obtained soon becomes clouded and friable. However, the chemist Callenberg has patented a process for the purification of artificial camphor. This new body, having the addition of naphthaline, furnishes, so claimed, an uninflammable and unexplodable celluloid.

The following have been proposed as substitutes for camphor: (1) The carbonic and phosphoric ethers of various phenols; (2) the thio-derivatives of the phenolic phosphates; (3) the ethylic and methylic ethers of sebacic acid, obtained by oxidation of castor or cocoa oil; 40 kilogrammes of these ethers are sufficient for 100 kilogrammes of nitro-cellulose; (4) naphthaline, of which several properties are similar to those of camphor, but the odor is disagreeable and subsists in the celluloid; (5) certain hydro-carbon substituted derivatives of naphthaline, which do not possess an unpleasant odor; (6) various aromatic sulphones and sulphonated derivatives; the chloride, amide, and anilide of sulphonic paratoluene acid, but the celluloid obtained with these substances becomes opaque, in consequence of the spontaneous crystallization of the products; (7) the acetylated derivatives and various organic ethers of saccharine matters.

Many attempts have been made to prepare uninflammable celluloids. J. Schnerber and L. Morane, among others, employ, along with nitro-cellulose, acetyl cellulose, which is free from this danger, and give the following directions for the preparation of a celluloid of good quality, and but slightly inflammable. Fifty parts by weight of camphor are dissolved in 55 parts of methylic or ethylic alcohol, and mixed with 100 parts of nitro-cellulose. The ingredients are left in contact for one or two days, and then are added 100 parts of acetyl cellulose dissolved in 50 parts of methylic alcohol or acetic ketone. The operation is continued as in the ordinary preparation.

M. H. Beau mixes calcium chloride in a solution of celluloid in acetic ketone, evaporates the solvent, and treats the residue like ordinary celluloid. He claims that the calcium chloride may be incorporated to the extent of 20 per cent of the mass. Such a product must, however, be quite hygroscopic.

The inflammability is also combated by the employment of aluminium, silica, or better, by methyl, ethyl, or amyl silicate.

For the preparation of galalith the casein of skimmed milk is the material generally employed. The casein is precipitated from the milk, which contains from 3 to 4 per cent of this, by means of rennet. When dry, it is a friable mass, yellowish white in color, and soluble in alkaline solutions, whence it can be reprecipitated by acids. The solutions of casein in ammonia or borax have been long employed in the dressing and printing of fabrics.

It was O. Schönfeld who first attempted to utilize casein for the preparation of a substance similar in appearance to celluloid, from milk, heated to 60 deg. C., with the addition of borax heated to 90 deg. After this action the casein is precipitated by means of various chlorides or other suitable mineral salts. The precipitate obtained is washed, pressed, and converted into slabs by means of grinding with soda or other solvents of the casein, and thus pressed in heated molds. The appearance of this product is that of celluloid or bone.

The commercial caseins of low price furnish turbid solutions. Lundberg has shown that casein in weak alkaline solutions is converted into alkaline albuminates without being clarified by repose, heating, or repeated filtrations. On the other hand, Adolph Prien has observed that a clear solution may be obtained by the action on casein of concentrated alkaline solutions, and the separation of the opaque soluble products. Commercial casein, mingled with thirteen times its weight of water, containing 2.5 per cent of soda of the weight of dry casein, yields a turbid solution. Progressive quantities of a 5 per cent solution of caustic soda are added. When the quantity of caustic soda reaches 14 per cent of the weight of the dry casein, the solution is readily separated from the whitish muddy precipitate.

But the products thus obtained become soft in water or are brittle when dry. Spitteler and Krische, uniting their efforts, have observed that the addition of formol to solutions of casein results after separation in products which become brittle and swell in water, but that these unfavorable properties disappear if the precipitate obtained by means of lead acetate is afterward submitted to the action of formol, especially if the casein separated is submitted to a hardening process by means of formol after drying. They compare their product with buffalo horn. Thus, after thirty-three days in water, the horn has absorbed from 15.5 to 18 per cent of water, and the new body, hardened by formol, from 16 to 23 per cent. Formol is also much employed in photography for hardening gelatine.

Galalith is colored by the addition of pigments to the casein solutions. The imitation of jet or ebony is secured by adding 2 per cent of soot to the solution, and precipitating by means of lead acetate. The precipitate is washed and drained on frames of filtering canvas. The drying is accomplished slowly. The mass, of deep gray appearance, is diluted in the formol and polished, and turns to a brilliant black.

Nickel sulphate gives a very beautiful green and cupric sulphate a greenish blue. Thus, by the same process and by employing various mineral colors, imitations of marble can be obtained.

For molding objects such as chessmen, umbrella handles, pen holders, hair pins, etc., it is of advantage to have the immersion in formol precede; however, the application of the pressure may take place after hardening, by softening the galalith slabs with hot water.

Signs may also be made of this product. Paper show cards covered with a concentrated solution of casein in ammonia, dried, and then covered with a solution of formol and lead acetate or zinc chloride, have a surface which may be polished and washed.

It may be useful to refer to two patents procured by the Vereinigte Gummiwaren-Fabriken. The first gives the method of replacing caustic alkalies with alkaline carbonates and thus obtaining a colorless galalith; 66 gallons of milk separated from insoluble substances and 7.7 pounds of sodium carbonate, that is, about 40 per cent, of the casein obtained, are employed. After standing undisturbed for a sufficient time, a colorless translucent casein is precipitated from the clear solution by means of acids after the muddy and insoluble mass has been deposited. The second patent is designed to give to commercial caseins the necessary plasticity for the production of galalith. It is sufficient to apply to the casein a very slight quantity of a dilute acid before the use of the rennet.

In an interesting communication to the Union of Austrian Chemists by Prof. Carl Hassack, he presented a comparative exhibit of the properties of celluloid and of galalith.

The two substances have nearly the same density; that of galalith varies according to its coloration, that is, according to the foreign substances incorporated, between 1.317 and 1.350; that of celluloid between 1.34 and 1.40. The hardness of galalith is a little less than that of limestone, that is, about 2.5, and that of celluloid 2 per cent less. A great difference consists in the fact that the celluloid is easily cut, while the galalith splits generally. Both are worked without trouble by means of the saw or the lathe. Both are susceptible of a beautiful polish, especially galalith.

In several respects galalith is inferior to celluloid. It is much less elastic. Objects of celluloid, strongly bent, return immediately to their primitive form, while those of galalith break by a slight flexion. So far, it has been possible to produce galalith in sheets only 0.08 inch or more in thickness, and never, like cellulose, in transparent sheets having the thinness of paper, nor in the shape of very fine thread. It is also not so well fashioned in the press. Still, by immersion of sufficient length in boiling water, it becomes soft and flexible, but can never be so well molded as celluloid.

In cold water galalith absorbs in six days, at the temperature of the laboratory, about 30 per cent of its weight of water; in twelve days 33 per cent; at the same time it swells and becomes of caseous consistency. Under the same conditions, celluloid scarcely increases to the extent of one per cent of its weight by the absorption of water.

Fats and organic solvents and dilute acids do not change galalith, but it swells in alkaline solutions, which have no effect on celluloid. Both substances are also insulators of electricity.

The greatest advantages of galalith over celluloid are that it is completely odorless and ignited with great difficulty. Presented to a flame, galalith is charred, while disengaging a disagreeable odor like horn; while celluloid is immediately ignited and disengages the thick vapor of camphor. In a word, its uninflammability and its high insulating power for electricity assure to galalith an extended future in the domain of electro-technics.

THE POSSIBILITIES OF CONCRETE CONSTRUCTION FROM THE STANDPOINT OF UTILITY AND ART.*

By WILLIAM L. PRICE.

IT is not my purpose to dwell especially upon the use of cement in the purely engineering side of building, although I believe that its use in that direction is in its infancy—and the general problem of concrete for heavy foundation work and reinforced with steel for structural work, has been covered by experts in those arts.

The accepted use of reinforced concrete as a structural material does, however, open up a field in architectural design that has been little considered. We have, both here and abroad, a comparatively large number of concrete buildings which are structurally good, but in most cases they are treated merely as a skeleton on which a building apparently of brick or stone is hung—a makeshift and a sham, whether the actual work is done by structural steel or a concrete frame developed therefrom.

But reinforced concrete used even as a skeleton offers opportunities for design not offered by any other material. A steel-frame building is no stiffer than its joints, and in buildings of greatly varying heights or loads allowance must be made in design to take up undistributed settlement, or serious cracking will result; while in concrete the building, if properly designed structurally, and properly built of proper materials, is a monolith.

In the Blenheim Hotel, at Atlantic City, we have an exaggerated case of uneven loading. The solarium is but two stories high, it covers an extent of 150 by 120 feet, it immediately joins the main structure which leaps at the juncture to twelve stories—a height to the dome of 155 feet—and next adjoining this mass is the main building, eight stories high, surrounded by outlying sun parlors and banquet rooms of two stories. And yet, in spite of this divergence in loads and the fact that this work was not all built at one time, there is not an eighth of an inch settlement in any part of the building. A steel building on the same foundations would probably show at least three inches of settlement, and it would not be safe to count on less.

It is my opinion that a considerable area of this building could have the foundations washed out without damage to the structure, nor does the heaviest wind so far encountered cause a perceptible vibration, even of the highest part of the building. These facts are not new as facts in engineering, but as architectural facts and inspirations they have been largely ignored. But if the cement manufacturers will stand by the architects this will come. Any falling off, however, in the quality and reliable characteristics of cement will be fatal, as a concrete building is either the best or the worst of constructions, and primarily the cement is the vital point, so that the cement man's first business is with himself. But while his responsibility may end there, his interests do not. The best of cements may be improperly or dishonestly used, poor sand, poor stone, poor mixing and placing alike will damn the construction, and it is in this direction that the greatest danger lies, and this danger is an imminent one. If buildings are to be designed by incompetent or ill-informed engineers and architects, no matter how much they know of design in other directions, the result will be disastrous, both to the cement men and to those among the architects who believe in the future and possibilities of cement.

It all looks so easy, just the building of boxes and the casting of concrete and steel in the molds, and where the law, or, better, knowledge, does not protect us, all sorts of liberties are going to be taken, owing to the desire to save materials and the large factor of safety usually and properly allowed.

To illustrate, when bids were taken on the Allegheny City station of the Pennsylvania Railroad a number of bids were received, varying considerably in amount, and, while the specifications called for 16,000 pounds stress upon the steel and 500 pounds on concrete, we found upon questioning the bidders that some of them had computed their steel as high as 22,000 pounds, and their concrete at 750 pounds. In fact, they were entirely frank about the matter, stating that there was no law in Allegheny on the subject, and that it was amply strong. Nor had they at all considered it incumbent on them to use the stone specified. Now, if this is to be the tendency of even large and reputable contractors, I can see grave dangers ahead, both from the effect of failures upon the public, and the passage of too stringent laws.

I turn from the dangers to the possibilities of the material architecturally. I cannot see much sense in the use of concrete as a substitute for block building material, although it will probably have its place if it is frankly treated as concrete and not as imitation stone. But the possibilities of design in concrete used this way are those of its competing materials, stone, brick, and terra cotta, so that I shall not dwell upon that, but try to point out something of what seems to me to be its greater possibility as a plastic material.

In block building, whether of stone, brick, or other material, the joints are an essential element of building, and as such should become an essential element of design to be accentuated rather than hidden, and in all characteristic and good architectural design you will find recognition of this fact. Take, for instance, any of the classic orders or their modifications in the Renaissance, and you will find a frank succession of blocks and columns set upon plinths, or directly on basement wall, cap, abacus, frieze and cornice, all built up stone upon stone with major joints marked by moldings, bands, and ornament, a logical, built structure. But if we attempt to follow such a system of design in a plastic material, or even a material like wood, the results are disastrous to true architecture. The design becomes a matter of external form, not of the true expression of methods and materials used. Concrete is built with shovel and trowel, and its proper ornamentation should be either cast in molds as built or such as can be run or fashioned on the work, with the addition of such color ornament as may be obtained by the use of terra cotta or other protecting material used as wall copings, roofs, pier caps, etc., and such other flat color ornamentation as may be produced by the use of tiles, marble, glass, or other material which is evidently applied to the surface. It is evident that this would and should make a wide departure from classic forms and accepted styles, that it means in fact a new architecture, although it will not be necessary to abandon all precedent. We shall want walls, windows, and doors in any case, and must learn to build them in their accepted forms. But in a material so plastic the forms of openings and moldings may be expected to vary much from those necessary to an architecture dependent on arches and lintels. There is more to be learned in the Spanish, or Californian and Mexican varieties of Spanish, than any other accepted type. Their plastered walls, tile roofs, and wall copings suggest concrete more than they do brick, and their domes and curved pediments are already suggestive of plastic rather than block construction.

I may perhaps be permitted to refer to the Blenheim Hotel as an example of an attempt to carry out some of these thoughts. At least there is no sugges-

* Read before the quarterly meeting of the Association of American Portland Cement Manufacturers.

tion of built structure in its simple wall openings, its exceedingly few and simple moldings, and its total lack of cornices. We have distinctly tried in it to use a solid wall, pierced by the simplest of openings, in an effort to reduce to a minimum the chopped-up appearance common with buildings that of necessity have many windows and small unbroken wall spaces. We have attempted, even where the wall was broken still further by bay windows, to preserve this feel of wall and have used the shadows thrown upon this broken surface by balconies, to give the relief usually obtained by ornamented cornices, and with the addition of a tile roof and some beautiful color obtained with Mercer tile, we have secured sufficient color and variety to make a building essentially plain in wall surface give a sense of richness not always obtained by the use of elaborate and expensive ornamental work in stone or terra cotta; and the use of a moderate amount of terra cotta where required for sills, copings, and other wall protection, has been made unusually important by modeling it in interesting and appropriate sea forms and coloring it a light green, by a glaze which has the additional advantage of destroying any semblance of stone and giving it a plastic character that seems appropriate to modeled ornament. It is along the line of simple and direct expression of the purpose and mode of construction of building that architecture grows when it is really growing, and cement in its manifold possibilities spreads before us a new field for the imaginative designer.

SURVEYING ON THE FARM.*

By A. S. KENYON, C.E.

LEVELING.

The Miner's Triangle.

THE earth's surface is not very smooth, and vertical measurements, especially with regard to irrigation and water supply, roads, and drains, are essential. The ascertaining of slopes and the relative levels of points is called leveling.

Instruments are essential. A primitive, yet handy,

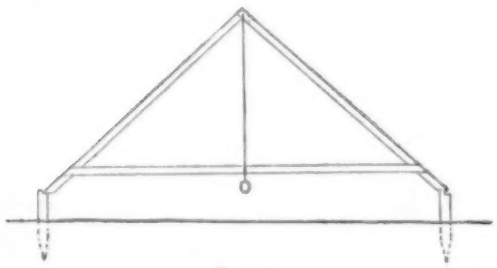


FIG. 1.

contrivance is known as the "miner's triangle." It is formed of battens about 3 inches by 1, made in the form of the letter A. (See Fig. 1.) The slant pieces are made exactly equal in length, and the cross-piece is fixed to the slant arms at equal distances. A plumb-bob is suspended from the point, and hangs a little lower than the horizontal piece. The ends of the slant pieces are exactly level when the plumb-bob string is truly in the middle of the cross-piece, where a mark has been carefully made. The opening between the ends is generally 11 feet, or one-sixth of a chain. At times it is as much as 16 feet 6 inches, one pole, or a quarter of a chain. Sometimes a spirit level is used on the horizontal piece in place of a plumb-bob. Before using it should be tested by driving two pegs the proper distance apart, on the edge of water, making the tops of the pegs the same height above the water. These pegs are exactly level, and when the instrument is placed on them, the plumb-bob string should be exactly on the mark, or, if a spirit level be employed, the bubble should be dead center. If not, the necessary corrections should be made. To set out a drain or grade line of any kind, adopt a particular fall, say, ½ inch per chain. Then, if the opening of the triangle be one-fourth of a chain, cut a step in the pegs of one-eighth of an inch in height, as shown in the figure. One leg of the triangle is placed on the starting peg, and another peg driven in under the other leg until the string or the bubble shows that it is level. On the next setting-up, the back leg is placed on the cut step, and so on, so that the step in each peg is ⅛ inch lower than that in the peg immediately behind it. The triangle is rather slow in use, and is only of service for levels along one line. Contouring of catchment areas or of irrigation paddocks requires a lighter and more generally useful instrument.

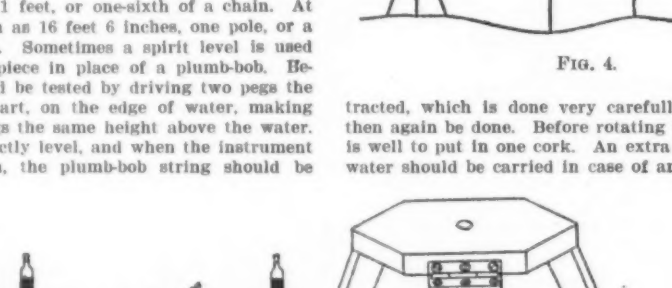


FIG. 2.

The Water Level.

The water level is free from the faults mentioned, and may be easily made. About the best form is that shown in Fig. 2. It consists of a piece of water pipe one-half inch or thereabout in diameter, with elbows screwed on each end. In the elbows are inserted medicine bottles with the bottoms cut off, and fixed in with plaster of Paris or shellac. Short pieces of glass tube, such as steam-gage glass, will answer the purpose as well. Corks for the bottles or tubes are required. At the middle of the tube, a nut or ring is soldered on, and a swinging joint made, as shown in the drawing. The support should be capable of turning in the head of the tripod, which may be readily contrived with four pieces of wood and three hinges. Horizontal rotating and vertical dipping motions are required. Many other ways of constructing this instrument will readily occur. All that is required are two glass tubes connected by some sort of water-tight tube, some few feet apart, and capable of being turned in any direction. The level is given by pouring water, preferably colored black with a little ink, into one end until it fills the connecting tube, and shows in the glass at the other end. A line sighted along the tops of the water in the glasses will be truly level. To shift the instrument, the corks are put in the glass ends, and the whole thing may be carried without risk of spilling. When setting up again, the instrument is set as nearly level by eye as possible, and one cork taken out. The water will not, however, move until the second cork is extracted, which is done very carefully. Sighting may then again be done. Before rotating the instrument, it is well to put in one cork. An extra supply of colored water should be carried in case of an accident. There is also required a staff 10 feet long, or more if practicable, marked off in feet and inches, made from a 3-inch by 1-inch batten. (See Fig. 3.) A cross-bar, blackened, with a box guide, formed as in the drawing, slides up and down the staff by means of a cord running through a hole near the top, and worked by the man holding the staff. Other instruments, such as drainage levels, consisting of a spirit level on a tripod or telescopic levels, are better avoided, as they are liable to get out of adjustment, and, once out, are not easily readjusted by persons unskilled in their use.

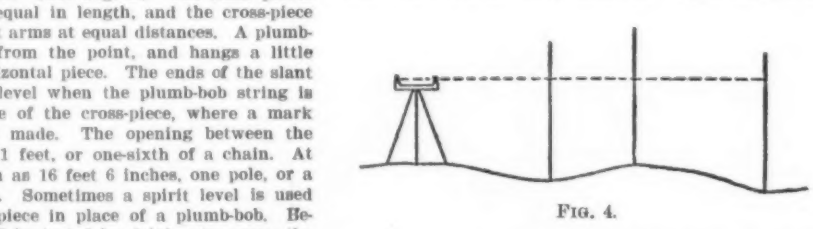


FIG. 4.

Leveling Operations.

The measurements of the levels of the surface, as shown by the readings of the staff, are really measurements downward from the level line along the tops of the water in the glasses to the ground. (See Fig. 4.) Consequently, the lower the ground surface, the greater is the reading. An increase in the reading as the staff is shifted shows a fall, while a diminution shows a rise. In operation, set up the level where a clear view can be obtained of all the points required, or as many of them as possible; it need not be on the line or any place in particular. Direct the tube at the starting point. Remove the corks after having brought it nearly level, and sight the staff held by the assistant. He will move the cross-bar up or down, as indicated, until its top is in line with the water surfaces. He will then note the reading of the cross-bar, or call it out to the observer at the instrument, as arranged. The staff is then taken to the new position, and another reading obtained. This is repeated until the staff is getting too far away for accurate sighting. The staff-man should then select some good fixed point, such as a stump, stone, or even a piece of hard ground, and hold the staff on it; it need not be on the line, nor a point of which the level is required. When the observer has taken the reading, the staff-man does not move, but waits until the observer has shifted the instrument to a new position, and taken another reading of the staff at the same point. The staff-man then proceeds to the next point the level of which is desired. The notes of the work should be kept, as shown in the following example:

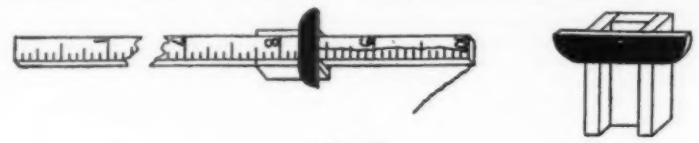


FIG. 3.

Distance.	Reading.	Rise.	Fall.	Surface Level.	Bed level.	Cutting.	Notes.
0	5' 6"	...	...	100' 0"	98' 0"	2' 0"	Dam bank.
50 links	6' 3"	...	0' 9"	99' 3"	...	1' 3"	
100 "	4' 2"	2' 1"	...	101' 4"	97' 11"	3' 5"	
150 "	4' 0"	0' 2"	...	101' 6"	...	3' 7"	
200 "	3' 9"	0' 3"	...	101' 9"	97' 10"	3' 11"	
	2' 9"	1' 0"	...	102' 9"	...	...	On stump.
	3' 2"	...	...	...	...	...	
250 "	4' 7"	...	1' 5"	101' 4"	...	3' 6"	
300 "	4' 9"	...	0' 2"	101' 2"	97' 9"	3' 5"	

In the first column is noted the distance along the line at which the reading is taken. In the second, the readings themselves are put down. When a change is made a horizontal line is drawn under the last reading noted, before moving the instrument, that is, the reading of the point at which the staff is to be read twice. The third and fourth columns are then filled in by subtracting a reading from the one next to it. When the second of two readings is the bigger, there has been a fall in the ground, as already explained, and *vice versa* there is a rise when the first reading is the greater. In the case of the two readings separated by the horizontal line no subtraction is made, as these, being at the same point, and of course at the same level, cannot consequently show a rise or a fall. If the level of the surface at the starting point, 0 links, is not known, it is customary to commence the fifth column with 100 feet, that is to assume, for the purposes of comparison, that the surface level at 0 links is 100 feet. The surface levels at the other points are found by subtracting the falls and adding the rises, as shown in columns 3 and 4. Columns 6 and 7 have been added to show the application of the results thus obtained to a case of draining. In the sixth column, the bed levels of an assumed channel are set down, the

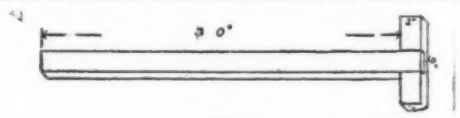


FIG. 5.

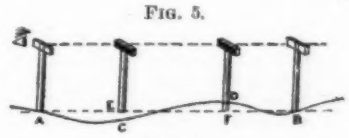


FIG. 6.

channel having a depth of 2 feet at the start, and a fall of 1 inch per chain. The differences between these bed levels and the surface levels in column 5 give the depths of cutting required. In the last column any notes or remarks which may be required to make the figures clear and intelligible are put down. By running lines at right angles to a base line, the whole of a paddock, or any area, may be leveled, or, as this operation is termed, "gridironed." Catch drains running on the contours, that is, the lines of equal level, check banks for irrigation, also preferably on contours, or drainage channels at right angles to the contours, may then be located and set out. Should a line require to be run with a tolerably uniform cutting with a known gradient or fall, the staff-man, after the first

* The Journal of the Department of Agriculture of Victoria,

reading is taken, raises the cross-bar the required fall for one chain, say, one-half inch, and paces out a chain in the probable direction. If the reading is exactly on the cross-bar, the cutting at this point will be the same as at the starting point; if it be not upon it, the cutting will be more or less, and the observer must decide whether it will be worth while shifting the staff—and the line of channel—to save the extra amount of cutting or bank shown. The cross-bar is then raised another one-half inch, giving again a fall, and another chain is set out. The observer must use his discretion as to the extent shortening the line will compensate for extra work.

Boning Rods.

Boning rods are often of use in grading a section of ground—such as the bed of a channel or surface of a road—between two points whose levels are given and which are not too far apart up to, say, five chains. A set of three is required, all equal in length and made T-shaped, as shown in Fig. 5, and out of, say, 2-inch by 1-inch soft wood. The main points to be borne in mind when making the rods are—first, make all the rods the same length; second, get the cross-head truly square to the blade; third, make the top or sighting edge of the cross-head as straight and sharp as possible. The method of using the rods is shown in Fig. 6. *ACDB* is the section of a portion of a road bed it is desired to grade, *A* and *B* being points whose levels are known. It is desired to fill in or trim off the ground between *A* and *B*, so that the grade in the line joining them will be uniform. The operation proceeds as follows: One assistant places his rod vertically at *B*, while the observer places his eye just behind the top edge of his rod held upright at *A*. A second assistant holds the third rod at the point *C*. He raises the rod until its top edge is in line with the sighting edges of the rods at *A* and *B*, as seen by the observer's eye. The rods all being of equal height, the bottom of the rod at *C* is therefore on the true grade line between *A* and *B*. A peg is driven in with its top flush with the bottom of the rod. Similarly the ground is dug away at, say, *D*, until the top of the rod held there is, as before, in line with the tops of those at *A* and *B*. A peg is also put in at this point. By these means, the grade line can be established at any number of points between *A* and *B*, as close as required. It is, of course, obvious that the rods must be held truly vertical to insure good results. For short sights no special trouble need be taken to prepare the sighting edges of the rods. For long ones, however, the best results are secured by whitening the cross-head of the far rod and holding it against a black background. If the cross-head of the intermediate rod be blackened, the two edges can be brought quite sharply into line with the sighting edge of the rod at the observer's end, and, on a clear day, sufficiently good work may be done up to distances of eight to ten chains.

HOW TO MAKE A GLIDING MACHINE.*

By LIVINGSTON WRIGHT and GORDON JOHNSON.

IN the construction of a glider only the very best spruce should be used. No piece should be put into the machine which is not absolutely free from knots and is not straight-grained. The cuts show design, and also give full size of cross section of the pieces.

Procure four sticks 20 feet long, two with a cross section like *A* and two like *B*. If this length cannot be obtained in one piece get two pieces and dovetail them, gluing them carefully and then wrapping them with No. 6 boot thread.

Procure twelve sticks 4 feet long, with a cross section like *D*. Procure a roll of No. 12 piano wire.

Lay the long sticks having the cross section *A* on the floor with the narrow rounded edge up and 4 feet apart. Between them, beginning at the end, lay edge up six pieces having the cross section *D*. Two of these should be placed a foot on each side of the center, and the other two should divide equally the other two spaces. Be sure that the ends of the short sticks exactly fit the contour of the long sticks where they touch, and then glue them to the long sticks, thus making a frame of five rectangles—and be sure that they are rectangles. The short sticks must be absolutely at right angles with the long sticks. Nail down pieces to hold the frame secure until dry. When dry lash with No. 6 boot thread. To do this tie around one stick, wind down around the other stick, and then back around the first stick on the other side, etc., using a coating of glue as you wind to hold the threads together. The other two long sticks are to be treated in the same manner, thus making two frames. These frames are then guyed diagonally with the piano wire, beginning at the end of the frame. The strength and rigidity of the structure depend on the care with which this is done. The winding of the wire at the different points will give a sufficient hold, although a little solder on the wire will help. Be careful in soldering not to heat the wire much, or it will weaken.

Procure four dozen sticks 4 feet long, having a cross section like *E*, and have them steamed and bent to the shape given in Fig. 3 and lettered *E*. These are the ribs to hold the cloth in place.

Stand the two frames up, the frame with the stick *A* having the rounded corners pointed away from the other frame. This frame is the forward frame of the machine. Place the other three feet away from it. The ribs, *E*, are now lashed to the front frame at their ends nearest the rise of the curves (this being the front), and the rear frame is lashed one foot in from the rear end.

Lash the ribs one foot apart for the full length of the upper surface, and do the same for the lower surface, except in the case of the space between the middle uprights, which is left vacant for the operator's body. Forty-one ribs are used for the main surface, and seven for the rudder.

There will now be a form of truss, and there will be six rectangles to be guyed diagonally. When this is done, test the strength of the truss by placing it on two saw horses. Place one under the first upright in from each end, and bear your whole weight on the middle. Observe whether there is any give, or if the structure is quite rigid. It should be made rigid before proceeding farther in construction.

Procure twenty yards of silk percaline for the surfaces. The front edge of the cloth is pasted around the front transverse stick. The cloth is stretched tightly above the ribs, and fastened to the rear of each rib. As the rear transverse stick is exposed to the air, it is protected by a long narrow strip of cloth pasted to the surface of the under side. The ribs may also be inclosed in the same manner. This strengthens the surface, and reduces the resistance offered by the air in the flight of the machine.

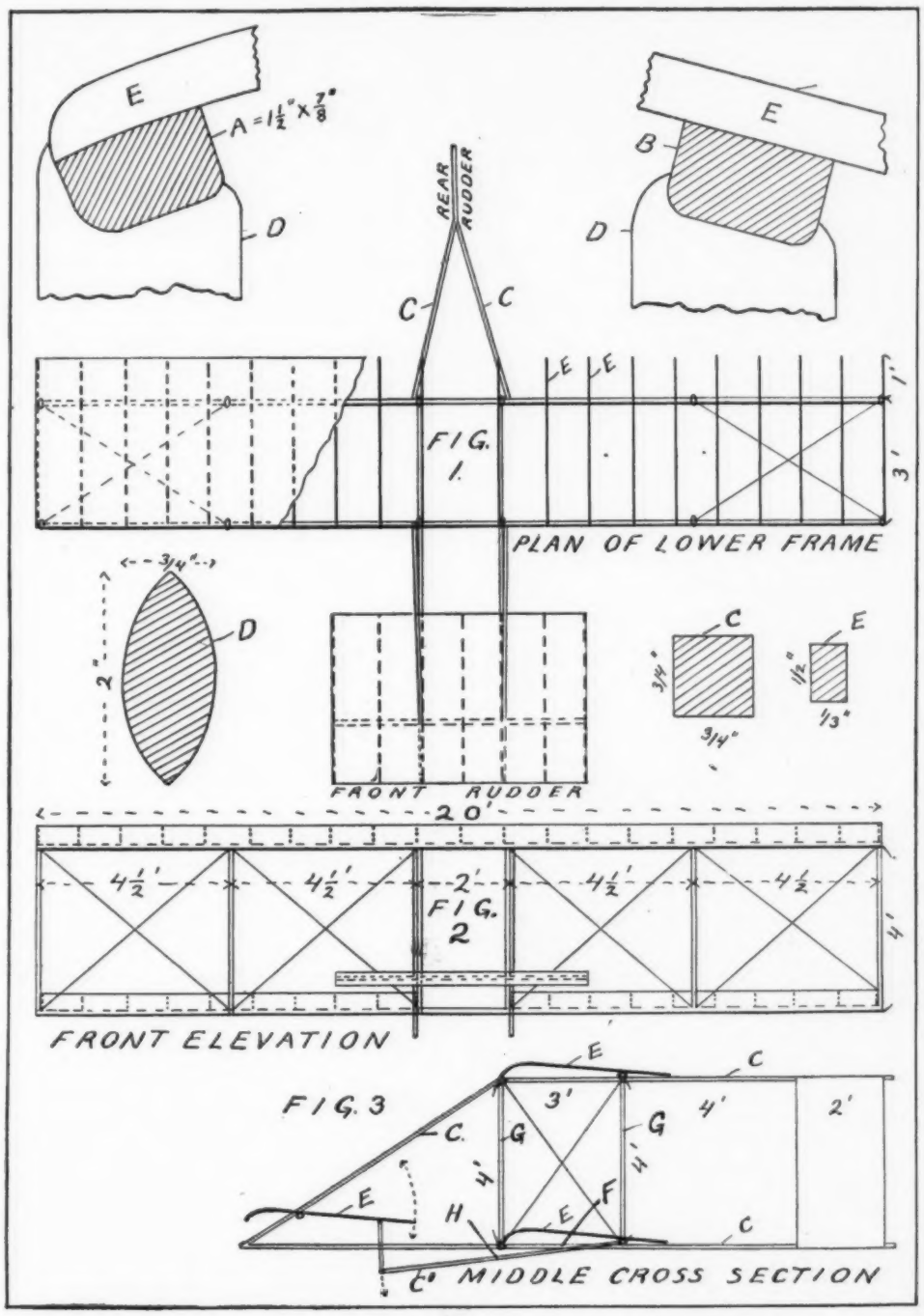
The lower surface is made in the same way, except that the center space is left uncovered for the operator.

The rudder is constructed by taking two strips of wood 6 feet long and with a cross section like *C*. To these lash securely the seven ribs with the end nearest the curve forward. The ribs are to be placed a foot apart. Guy them carefully with stretches of the piano wire along the diagonals, formed by the sticks and the ribs. Pivot the rudder so that its rear edge can be raised or lowered. To support and operate the rudder, procure four pieces with the cross section *C* and about 6 feet long. Lash and guy these in front of the frame as shown in Fig. 3. The rudder is connected by two sticks with the two rods, one of which is shown in Fig. 3 lettered *C'*. These rods are fastened at their rear ends behind the operator, who is supported by the armpits at about *F* (Fig. 3) and grasps rods *C'* at about *H*.

Fasten on the main transverse sticks of the lower surface two sticks just wide enough apart so that the body of the operator can go between them. In flight these sticks support the operator under the armpits, and must be adjusted as to distance apart and strength to the weight and size of the operator.

The great tendency of curved surfaces is to dive forward; but by pressing down on rods *C'*, one being held in each hand, the rear end of the rudder is lowered, and this tendency will be overcome. There is no danger of the operator not having leverage enough to manage the rudder in a wind. He will be supported in the air by the cross pieces under his armpits, and with his hands gripping the rudder rods he can if necessary bring his entire weight to bear to move the rudder.

The rear rudder is not movable, and is simply to keep the machine head to the wind, which is the only safe position for the novice. Fig. 1 shows how this is arranged. It is a plane surface.



WORKING DRAWINGS OF HOME MADE GLIDING MACHINE.

The cost of materials of such a glider need not exceed $15. Wire will cost $1, wood about $5, and cloth of a cheap but sufficiently strong grade, 25 cents a yard, or $5. These are estimates. The labor is of course the greatest expense, and if the machine is built by a carpenter the cost will probably amount to as much as $60 or $70. The Blue Hill kites now in use cost fully as much as this. Almost all of it is chargeable to the labor and time required to make all the parts carefully and strongly. With leisure, however, a man could easily make his own glider, the only really difficult thing being the joints and the guying. Any mill can turn out sticks to shape on a molding machine, and do it in large quantities almost as cheaply as a carpenter could do it in small quantities.

With a machine of this sort much pleasure may be had with little danger, if the operator be careful. To make a glide, put the machine under the armpits, holding rods *C'* one in each hand, and run with it

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

against the wind. Instantly all weight will be gone, and you will be lifted off your feet. You will be surprised at the lift you will experience. Begin with making short jumps, and then gradually take longer ones. A half dozen trials will convince you of the fun that can be obtained, and how to obtain it better than all the directions that can be written.

[Continued from SUPPLEMENT No. 1580, page 25319.]

VALUABLE ALLOYS.—III.

WHITE METAL.

THE so-called white metals are employed almost exclusively for bearings. In the technology of mechanics an accurate distinction is made between the different kinds of metals for bearings; and they may be classed in two groups, red-brass and white metal. The red-brass bearings are characterized by great hardness and power of resistance, and are principally used for bearings of heavily-loaded and rapidly-revolving axles. For the axles of large and heavy flywheels, revolving at great speed, bearings of red-brass are preferable to white metal, though more expensive.

In recent years many machinists have found it advantageous to substitute for the soft alloys generally in use for bearings a metal almost as hard as the axle itself. Phosphor-bronze is frequently employed for this purpose, as it can easily be made as hard as wrought or cast steel. In this case the metal is used in a thin layer, and serves only, as it were, to fill out the small interstices caused by wear on the axle and bearing, the latter being usually made of some rather easily-fusible alloy of lead and tin. Such bearings are very durable, but expensive, and can only be used for large machines. For small machines, running gently and uniformly, white-metal bearings are preferred, and do excellent work, if the axle is not too heavily loaded. For axles which have a high rate of revolution, bearings made of quite hard metals are chosen, and with proper care—which, indeed, must be given to bearings of any material—they will last for a long time without needing repair.

WHITE METALS FOR BEARINGS.

	Tin.	Antimony.	Zinc.	Iron.	Lead.	Copper.
German, light loads	85.00	10.00	.....	.....	.....	5.00
German, light loads	82.00	11.00	.....	.....	.....	7.00
German, light loads	80.00	12.00	.....	.....	.....	8.00
German, light loads	76.00	17.00	.....	.....	.....	7.00
German, light loads	8.00	1.00	5.00	.....	3.00	1.00
German, heavy loads	90.00	8.00	.....	.....	.....	2.00
German, heavy loads	86.81	7.62	.....	.....	.....	5.57
English, heavy loads	17.47	.....	76.14	.....	.....	5.62
English, medium loads	76.70	15.50	.....	.....	.....	7.80
English, medium loads	72.00	26.00	.....	.....	.....	2.00
For mills	15.00	.....	40.00	.....	42.00	3.00
For mills	.....	1.00	5.00	.....	5.00	.....
For mills	.....	1.00	10.00	.....	2.00	.....
Heavy axles	72.70	18.20	.....	.....	.....	9.10
Heavy axles	38.00	6.00	47.00	.....	4.00	1.00
Rapidly revolving axles	17.00	77.00	.....	.....	.....	6.00
Very hard metal	55.00	.....	.....	70.00	.....	2.50
Very hard metal	12.00	82.00	2.00	.....	.....	4.00
Cheap metal	2.00	2.00	88.00	.....	.....	8.00
Cheap metal	1.50	1.50	90.00	.....	.....	7.00

CUPRO-MANGANESE.

The alloys of copper with manganese have a beautiful silvery color, considerable ductility, great hardness and tenacity, and are more readily fusible than ordinary bronze. A special characteristic is that they fill out the molds very exactly, without the formation of blowholes, and present no difficulties in casting.

Cupro-manganese is suitable for many purposes for which nothing else but bronze can advantageously be used, and the cost of its production is no greater than that of genuine bronze. In preparing the alloy, the copper is used in the form of fine grains, obtained by pouring melted copper into cold water. These copper grains are mixed with the dry oxide of manganese, and the mixture put into a crucible holding about 66 pounds. Enough space must be left in the crucible to allow a thick cover of charcoal, as the manganese oxidizes easily. The crucible is placed in a well-drawing wind-furnace and subjected to a strong white heat. The oxide of manganese is completely reduced to manganese, which at once combines with the copper to form an alloy. In order to prevent, as far as possible, the access of air to the fusing mass, it is advisable to cover the crucible with a lid, which has an aperture in the center for the escape of the carbonic oxide formed during the reduction.

When it is supposed that the reduction is complete, and the metals fused, the lid is removed and the contents of the crucible stirred with an iron rod, in order to make the alloy as homogeneous as possible. By repeated remelting of the cupro-manganese a considerable quantity of the manganese is reconverted into oxide; it is therefore advisable to make the casts directly from the crucible. When poured out, the alloy rapidly solidifies, and resembles in appearance good German silver. Another reason for avoiding remelting is that the crucible is strongly attacked by the cupro-manganese, and can be used but a few times.

The best kinds of cupro-manganese contain between 10 and 30 per cent of manganese. They have a beautiful white color, are hard, tougher than copper, and can be worked under the hammer or with rolls. Some varieties of cupro-manganese which are especially valuable for technical purposes are given below.

	I.	II.	III.	IV.
Copper	75	60	65	60
Manganese	25	25	20	20
Zinc	..	15	5	..
Tin	..	..	..	10
Nickel	..	..	10	10

ALLOYS OF COPPER AND IRON.

The alloys of copper and iron are little used in the industries at the present day, but it would seem that in earlier times they were frequently prepared for the purpose of giving a considerable degree of hardness to copper; for in antique casts, consisting principally of copper, we regularly find quite large quantities of iron, which leads to the supposition that they were added intentionally.

These alloys, when of a certain composition, have considerable strength and hardness. With an increase in the quantity of the iron the hardness increases, but the solidity is lessened. A copper and iron alloy of considerable strength, and at the same time very hard, is made of copper 66 parts, iron 34. These alloys acquire, on exposure to air, an ugly color inclining toward black, and are therefore not adapted for articles of art.

MIRA METAL.

This alloy is characterized by its power of resisting the action of acids, and is therefore especially adapted to making cocks, pipes, etc., which are to come in contact with acid fluids. It is composed of copper, zinc, lead, tin, iron, nickel, cobalt, and antimony, in the following proportions:

Copper	74.755
Zinc	0.615
Lead	16.350
Tin	0.910
Iron	0.430
Nickel } Cobalt }	0.240
Antimony	6.785

ALLOYS OF COPPER AND ARSENIC.

Arsenic imparts to copper a very fine white color, and makes it very hard and brittle. Before German silver was known, these alloys were sometimes used for the manufacture of such cast articles as were not to come in contact with iron. When exposed to the air, they soon lose their whiteness and take on a brownish shade. On account of this, as well as the poisonous character of the arsenic, they are very little used at the present time.

Alloys of copper and arsenic are best prepared by pressing firmly into a crucible a mixture of 70 parts of copper and 30 of arsenic (the copper to be used in the form of fine shavings) and fusing this mixture in a furnace with a good draft, under a cover of glass.

ALUMINIUM BRONZE.

Aluminium is a metal whose properties are very materially influenced by a proportionately small addition of copper. Alloys of 99 per cent aluminium and 1 per cent of copper are hard, brittle, and bluish in color; 95 per cent of aluminium and 5 per cent of copper gives an alloy which can be hammered, but with 10 per cent of copper the metal can no longer be worked. With 80 per cent and upward of copper, are obtained alloys of a beautiful yellow color, and these mixtures, containing from 5 to 10 per cent of aluminium and from 90 to 95 per cent of copper, are the genuine aluminium bronzes. The 10 per cent alloys are of a pure golden yellow color; with 5 per cent of aluminium they are reddish yellow, like gold heavily alloyed with copper, and a 2 per cent mixture is of an almost pure copper red. As the proportion of copper increases, the brittleness is diminished, and alloys containing 10 per cent and less of aluminium can be used for industrial purposes, the best consisting of 90 per cent of copper and 10 per cent of aluminium. The hardness of this alloy approaches that of the genuine bronzes, whence its name. It can be stretched out into thin sheets between rollers, worked under the hammer, and shaped as desired by beating or pressure, in powerful stamping presses. On account of its hardness it takes a fine polish, and its peculiar greenish-gold color resembles that of gold alloyed with copper and silver together.

Alloys with a still greater proportion of copper approach this metal more and more nearly in their character; the color of an alloy, for instance, composed of 95 per cent of copper and 5 per cent of aluminium, can be distinguished from pure gold only by direct comparison, and the metal is very hard, and also very malleable.

Aluminium bronze is prepared by melting the finest copper in a crucible, and adding the aluminium. The copper is cooled thereby to the thickly fluid point, but at the moment of the combination of the two metals, so much heat is released that the alloy becomes white hot and thinly fluid. Aluminium bronze thus prepared is usually brittle, and acquires its best qualities only after having been remelted several times. It may be remarked that in order to obtain a bronze of the best quality, only the very purest copper must be used; with an inferior quality of copper, all labor is wasted.

Aluminium bronze is not affected by exposure to the air; and its beautiful color makes it very suitable for manufacturing various ornamental articles, including clock-cases, door-knobs, etc.

Aluminium bronze wire is as strong as good steel wire, and castings made from it as hard as steely iron; its resistance to bending or sagging is three times as great as that of ordnance metal, and forty-four times as great as that of good brass. These properties, combined with its beautiful color and its unchangeableness, would seem to promise a very extended use for it in the manufacture of machinery, and especially for mechanical instruments where great precision is required.

SUN-BRONZE.

The alloy called sun-bronze contains 10 per cent of aluminium, 30 or 40 per cent of copper, and 40 per cent of cobalt. The mixture known by the name of metalline has 25 per cent of aluminium, 30 of copper, 10 of iron, and 35 of cobalt.

These alloys melt at a point approaching the melting point of copper, are tenacious, ductile, and very hard.

ALLOYS OF LEAD AND TIN.

In former times, before porcelain came into general use, alloys of tin and lead were very extensively used for the manufacture of the so-called tinware, which probably never consisted of pure tin, but always of a mixture of tin and lead. Tin is one of those metals which is not at all susceptible to the action of acids, while lead, on the other hand, is very easily attacked by them. In such alloys, consequently, used for cooking utensils, the amount of lead must be limited, and should properly not exceed 10 or 15 per cent; but cases have been known in which the so-called tin contained a third part, by weight, of lead.

Alloys containing from 10 to 15 per cent of lead have a beautiful white color, are considerably harder than pure tin, and much cheaper. Many alloys of tin and lead are very lustrous, and are used for stage jewelry and mirrors for reflecting the light of lamps, etc. An especially brilliant alloy is called "Fahlun brilliants." It is used for stage jewelry, and consists of 29 parts of tin and 19 of lead. It is poured into molds faceted in the same way as diamonds, and when seen by artificial light, the effect is that of diamonds. Other alloys of tin and lead are employed in the manufacture of toys. These must fill the molds well, and must also be cheap, and therefore as much as 50 per cent of lead is used. Toys can also be made from type metal, which is even cheaper than the alloys of tin and lead, but has the disadvantage of readily breaking if the articles are sharply bent. The alloys of tin and lead give very good castings, if sharp iron or brass molds are used.

BRITANNIA METAL.

Britannia metal is an alloy consisting principally of tin and antimony. Many varieties contain only these two metals, and may be considered simply as tin hardened with antimony, while others contain, in addition, certain quantities of copper, sometimes lead, and occasionally, though rarely on account of its cost, bismuth.

Britannia metal is always of a silvery white color, with a bluish tinge, and its hardness makes it capable of taking a high polish, which is not lost through exposure to the air.

Ninety per cent of tin and 10 per cent of antimony gives a composition which is the best for many purposes, especially for casting, as it fills out the molds well, and is readily fusible. In some cases, where articles made from it are to be subjected to constant wear, a harder alloy is required. In the proportions given above, the metal is indeed much harder than tin, but would still soon give way under usage.

A table is appended, giving the composition of some of the varieties of Britannia metal and their special names.

	Tin.	Antimony.	Copper.	Zinc.	Lead.
English	81.96	16.25	1.84	....	...
English	90.62	7.81	1.46	....	...
English	90.1	6.3	3.1	0.5	...
English	85.4	9.66	0.81	3.06	...
Pewter	81.2	5.7	1.60	....	11.5
Pewter	89.3	7.6	1.8	....	1.8
Tutania	91.4	....	0.7	0.3	7.6
Queen's metal	88.5	7.1	3.5	0.9	...
German	72.	24.	4.	....	...
German	84.	9.	2.	5.	...
German (for casting)	20.	64.	10.	6.	...
Malleable (for casting)	48.	....	3.	48.	1.

Britannia metal is prepared by melting the copper alone first, then adding a part of the tin and the whole of the antimony. The heat can then be quickly moderated, as the melting point of the new alloy is much lower than that of copper. Finally, the rest of the tin is added, and the mixture stirred constantly for some time to make it thoroughly homogeneous.

BIDDERY METAL.

Biddery metal derives its name from the city in the East Indies from whence it was first brought into commerce. It may be included under the general name of Britannia metal, but differs from this in containing lead in the place of antimony.

The composition of the genuine Indian Biddery metal (frequently imitated in England) is about as follows:

	Per cent.	Per cent.
Copper	3.5	11.4
Zinc	93.4	84.3
Tin	....	1.4
Lead	3.1	2.9

Among several other alloys which bear a certain resemblance to Britannia metal, two may be specially mentioned here, namely, Ashberry metal and Minofor metal. The composition of the former is as follows:

	I.	II.
Copper	2	3
Tin	8	79
Antimony	14	15
Zinc	1	2
Nickel	2	1

The so-called Minofor metal is composed of copper, tin, antimony, zinc, and iron in the following proportions:

	I.	II.
Copper	3.26	4
Tin	67.53	66
Antimony	17.00	20
Zinc	8.94	9
Iron	.....	1

Both these alloys are sometimes used in England for purposes where the ordinary Britannia metal, 2 parts tin and 1 part antimony, might equally well be employed; the latter surpasses both of them in beauty of color, but they are, on the other hand, harder.

TYPE METAL.

An alloy which is to serve for type metal must allow of being readily cast, fill out the molds sharply, and be as hard as possible. It is difficult to satisfy all these requirements entirely, but an alloy of antimony and lead answers the purpose best. At the present day there are a great many formulæ for type metal in which other metals besides lead and antimony are used, either to make the alloy more readily fusible, as in the case of additions of bismuth, or to give it greater power of resistance, the latter being of especial importance in newspaper types, which are subjected to constant use. Copper and iron have been recommended for this purpose, but the fusibility of the alloys is greatly impaired by these, and the manufacture of the types is consequently more difficult than with an alloy of lead and antimony alone. In the following table some alloys suitable for casting type are given:

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Lead	3	5	10	10	70	60	55	55	100	6
Antimony	1	1	1	2	18	20	25	30	30	..
Copper	..	..	..	..	2	..	..	..	8	4
Bismuth	..	..	..	1	..	..	..	..	2	..
Zinc	..	..	..	..	..	..	..	..	..	90
Tin	..	..	..	..	10	20	20	15	20	..
Nickel	..	..	..	..	.	..	..	..	8	..

The French and English types contain a certain amount of tin, as shown by the following analyses:

	English Types.			French
	I.	II.	III.	Types.
Lead	69.2	61.3	55.	55
Antimony	19.5	18.8	22.7	30
Tin	9.1	20.2	22.1	15
Copper	1.7	....	....	..

Ledebur gives the composition of type metal as follows:

	I.	II.	III.	IV.
Lead	75	60	80	82
Antimony	23	25	20	14.8
Tin	22	15	..	3.2

I. ordinary, II. fine, III. alloy for sticks, IV. for stereotype plates.

Erhardt recommends the following as being both ductile and hard:

Zinc	89 to 93
Tin	9 to 6
Lead	2 to 4
Copper	2 to 4

The tin is first melted, and the lead, zinc, and copper added successively.

The alloy given by Karmarsch, consisting of 16 parts of tin and 1 of antimony, is much harder than lead, melts at 264 deg. C. (about 507 deg. F.) and can be drawn out into wire. It becomes flexible by working, and can be used in the place of pure lead for many articles.

CADMIUM ALLOYS.

Lipowitz's Alloy.

This alloy is composed of cadmium 3 parts, tin 4, bismuth 15, and lead 8. The simplest method of preparation is to heat the metals, in small pieces, in a crucible, stirring constantly, as soon as fusion begins, with a stick of hard wood. The stirring is important, in order to prevent the metals, whose specific gravity varies considerably, from being deposited in layers. The alloy softens at 140 deg. F., and melts completely at 158 deg. F.

The color is silvery white, with a luster like polished silver, and the metal can be bent, hammered, and turned. These properties would make it valuable for many purposes where a beautiful appearance is of special importance, but on account of the considerable amount of cadmium and bismuth which it contains, it is rather expensive, and therefore limited in use. Casts of small animals, insects, lizards, etc., have been prepared from it, which were equal in sharpness to the best galvanoplastic work. Plaster of Paris is poured over the animal to be cast, and after sharp drying, the animal is removed and the mold filled up with Lipowitz's metal. The mold is placed in a vessel of water, and by heating to the boiling point the metal is melted, and deposited in the finest impressions of the mold.

This alloy is most excellent for soldering tin, lead, Britannia metal, and nickel, being especially adapted to the two latter metals on account of its silver white color. But here again its costliness prevents its general use, and cheaper alloys possessing the same properties have been sought. In cases where the silver white color and the low melting point are not of the first importance, the alloys given below may very well be used in the place of it.

Cadmium alloy (melting point 170 deg. F.): Cadmium 2, tin 3, lead 11, bismuth 16.

Cadmium alloy (melting point 167 deg. F.): Cadmium 10, tin 3, lead 8, bismuth 8.

Cadmium alloys (melting point 203 deg. F.):

	I.	II.	III.
Cadmium	1	1	1
Tin	2	3	1
Bismuth	3	5	2

A very fusible alloy, melting at 150 deg. F., is composed of tin 1 or 2 parts, lead 2 or 3, bismuth 4 or 15, cadmium 1 or 2.

Wood's alloy melts between 140 deg. and 161.5 deg. F. It is composed of lead 4 parts, tin 2, bismuth 5 to 8, cadmium 1 to 2. In color it resembles platinum, and is malleable to a certain extent.

Cadmium alloy (melting point 179.5 deg. F.): Cadmium 1, lead 6, bismuth 7.

This, like the preceding, can be used for soldering in hot water.

Cadmium alloy (melting point 300 deg. F.): Cadmium 2, tin 4, lead 2.

This is an excellent soft solder, with a melting point about 86 degrees below that of lead and tin alone.

CLICHÉ METAL.

An alloy consisting of lead 50 parts, tin 36, and cadmium 22.5, is remarkably well adapted to the manufacture of *clichés*, or cuts, since with as low a melting point as the *cliché* metals generally used (made of bismuth alloys) it combines the valuable property of greater hardness. With a *cliché* or plate of this metal a large number of sharp impressions can be obtained. —Translated from Krupp's Die Legierungen.

ELECTRICAL NOTES.

Marseilles is the best equipped city of France as regards electric tramway lines, and ranks among the best on the Continent in this respect. A large electric plant has been erected to supply the current, and it is laid out on the most modern principles. The total length of track for the electric lines is now about 125 miles, and it is proposed to lay some other lines in the city and suburbs to the extent of 35 miles. As to the mileage of electric lines per inhabitant, it is stated that Marseilles is now in the first rank among the European cities, seeing that it possesses 1.5 miles per 10,000 inhabitants. The next after it is Düsseldorf, with 0.91 mile. In 1904 the total number of passengers transported was 70 millions. The new electric station now contains four batteries of boilers having 220 square yards heating surface and a new battery of Babcock & Wilcox boilers. In the boiler plant has been installed a very complete system of mechanical stokers and coal conveyors. The electric outfit, which has been supplied by the French branch of the Thomson-Houston Company, consists of dynamos built after the American system, although the machines have been constructed at the Paris shops of the company. At present the electric plant contains five generating sets of 1,500 horse-power each.

The large electric station which is used to operate the Paris subway has received an important increase of late, owing to the opening up of the new sections of the road. When the station was first erected a few years ago it was equipped with boilers and engines, the latter being direct connected to large dynamos, to the extent of 8,500 horse-power. Space had been left in the building for the new machines which it was expected to add, and at present the second part of the plant is about completed by the addition of a new set of boilers and engines. The main dynamo hall lies in the middle of the building, with a boiler room along either side. About 11,000 horse-power has been added making the total capacity of the station near 20,000 horse-power. In the first case the engines were built by the Compagnie Alsacienne and the dynamos by the Schneider firm, but the second groups, while using the same type of engine, have Thomson-Houston dynamos, the latter having been built in France more or less after the American method of design. It is to be noted in this connection that the American type of motor is used on the cars of the subway, these having been furnished by the latter firm and the French Westinghouse Company, of Havre. The new boiler room is one of the best equipped on the Continent. Water is taken from the Seine, as the station lies on the banks. There are twenty-one boilers in the new plant. These have a grate surface of 6 square yards, and a water-heating surface of 300 square yards. The engines, of the upright cross-compound type, run at 80 revolutions per minute and give 4,000 horse-power each. Built with the engines are the dynamos which deliver alternating current on the three-phase system. This current is sent by underground cable to a number of substations in the city where it is converted to direct current at low tension for the subway.

A highly interesting problem has been recently solved by Mr. Adolf Herz, and is discussed in the Zeitschrift für Beleuchtungswesen. It is a well-known fact that the economy of a given illuminant increases as its absolute temperature rises, the maximum of radiation being gradually displaced toward the visible part of the spectrum as the temperature becomes higher; while the total luminous intensity of the illuminant, so far from increasing in an arithmetical proportion, rises far more rapidly. If, for instance, the temperature of bare platinum be raised from 800 deg. C. to 820 deg., its luminous intensity will increase to more than double its initial value; and if the temperature of a body at white heat be increased from 1 to 2, its luminous intensity will increase from 1 to 2^{12}, i. e., from 1 to 4,000. Now, it is impossible by means of ordinary flames to attain higher temperatures than, say, 1,800 to 2,000 deg. C., nor is it practicable by means of Auer burners to exceed a given, relatively low, economy of light production. Electric currents, on the other hand, afford means for considerably increasing the temperature of a body. An Auer glower or some other glower of convenient shape, consisting of metal oxides, is a perfect non-conductor of electricity at low temperatures, while it becomes a good conductor of electricity on being preheated to about a red heat (as known from the use of Nernst lamps). Mr. Herz utilizes this fact by supplying to a glower heated by a gas flame an electric current of convenient proportions, so that the glower, apart from the heating effect of the gas flame, is subjected to an additional increase in temperature due to the current. The luminous efficiency accordingly increases in extraordinary proportion.

SCIENCE NOTES.

The French word "vinaigre," from which the English word "vinegar" is derived, means sour wine. Two kinds of vinegar, white and red, made respectively from white and red wines, are produced. On account of the red color being undesirable for many purposes the white is usually preferred. "Sweet as sugar" and "sour as vinegar" are comparisons we often make. As opposite as those two qualities are, it is nevertheless true that the sourest substance is made from the sweetest.

The study of stability and instability furnishes the problems which the physicist and biologist alike attempt to solve. The two classes of problems differ principally in the fact that the conditions of the world of life are so incomparably more intricate than those of the world of matter that the biologist is compelled to abandon the attempt to determine the absolute amount of the influence of the various causes which have affected the existence of species. His conclusions are merely qualitative and general and he is almost universally compelled to refrain from asserting even in general terms what are the reasons which have rendered one form of animal life stable and persistent, and another unstable and evanescent. On the other hand, the physicist, as a general rule, does not rest satisfied unless he obtains a quantitative estimate of various causes and effects on the systems of matter which he discusses. Yet there are some problems of physical evolution in which the conditions are so complex that the physicist is driven, as is the biologist, to rest satisfied with qualitative rather than quantitative conclusions. But he is not content with such crude conclusions except in the last resort, and he generally prefers to proceed by a different method.

For nearly two centuries after the advent of the white man in America farming was confined to a narrow strip of land adjacent to the Atlantic; the population was sparse, and when a field became worn out the near-by woodland was cleared. As population increased, the younger generation crossed the Alleghenies to the Pacific. In its westward course this advancing host farmed virgin soils for a century. The marvelous development which has occurred in this country during the past century was made possible by the abundant fertility of the new lands brought under cultivation and the consequent abundance and cheapness of farm products. So long as plenty of fertile land remained unoccupied in the West the exhaustion of the older land in the East was a matter of concern only to the farmers of the older settled communities. But now we are confronted by the necessity of tilling soils whose ability to produce satisfactory crops has been greatly impaired. There is even a perceptible flow of immigration from the high-priced lands of the Middle West to the depleted lands of the Atlantic seaboard. This has been made possible by the recent remarkable development of agricultural science, which has demonstrated the feasibility of restoring fertility to exhausted soils. Agricultural science is also responsible for the present movement from the city to the country. The conditions of country life have been alleviated; the farm has been made attractive by adding the zest of intellectual occupation in the splendid agricultural literature of the day; and farming, when intelligently followed, has been made profitable, even on lands that were formerly unproductive.

Up to the time of the establishment of the registration of vital statistics in England, in 1839, the stream of public health science, although full of promise, was only a slender thread, but when the results of registration were fully enlisted in its service it visibly widened and deepened. Epidemiology, as has been said, had the honor of giving birth to the science in 1767, and it added to its offspring a rich endowment when, in 1854, Dr. John Snow proved that the water of the Broad Street well in London had caused an epidemic, in which more than six hundred persons died of Asiatic cholera. The stream of public health science was still further enlarged and quickened by the revelation in and after the sixties of the simple causes of numerous epidemics of trichinosis and of typhoid fever, the latter sometimes through milk. There was an extraordinary popular awakening in England to the importance of sanitation and public health measures in the middle of the nineteenth century, but we look for some time in vain for any marked inosculation between public health science and other sciences, such as physics, chemistry, microscopy, bacteriology, climatology, engineering, or education. We have, to be sure, minor contributions from the microscopists, such, for example, as that from Dr. Hassall, who, in 1850, made a careful microscopical examination of the water supply of London and showed the presence in the public drinking water of muscle fibers, intestinal parasites

and other materials, plainly derived from sewage; but it was not until Pettenkofer and his disciples, in Germany, and Angus Smith and others, in England, began their splendid chemical investigation that the tributary stream of *sanitary chemistry* enlarged materially that of public health science.

Humboldt, in his chapter on "Climate," after comparing the climates and fruits of Europe, says: "These comparisons demonstrate how important is the diversity of the distribution of heat throughout the different seasons of the year for the same mean annual temperature, as far as concerns vegetation and the culture of the fields and orchards, and as well as regards our own well-being as a consequence of these conditions. The lines which I call isochimenal and isotheral (lines of equal temperature for winter and summer) are not parallel to the isothermal lines (lines of equal annual temperature) in those countries where —notwithstanding the myrtle grows wild in its natural state, and where no snow falls during the winter—the temperature of summer and fall scarcely suffices to bring apples to full maturity. If to give a potable wine the vine shuns the islands and nearly all sea coasts, even those of the west, the cause is not only in the moderate heat of summer upon the seashore, a circumstance which is shown by thermometers exposed in the open air and in the shade, but it consists still more in the difference between direct and diffused light, between a clear sky and one veiled with clouds, a difference which is still unappreciated, although its efficaciousness may be proved by other phenomena, as, for example, the union of a mixture of chlorine and hydrogen." Humboldt adds: "I have endeavored for a long time to call the attention of scientists and physiologists to this difference; in other words, to the yet unmeasured heat which direct light develops locally in the cell of the living plant." (Cosmos, t. I, pp. 347-349.)

ENGINEERING NOTES.

Hand chipping should be replaced by pneumatic chippers, hand riveting by pneumatic or hydraulic riveters, hand filing by emery wheels or portable electric grinders, portable drills to replace the old ratchet. Planers should be supplemented by milling machines to cut down the number of operations, lathes should be supplemented by grinding machines. Portable tools are usually thought of as being small and light, and the majority of them are, but sometimes the work is so large that it cannot be taken to the machines, and consequently the machine has to be taken to the work, necessitating large and heavy portable planers, drills, etc., such, for example, as were used in the shops of the Westinghouse Electric and Manufacturing Company, at East Pittsburg, in machining large generator frames, some of these frames being laid out by means of a transit, as the ordinary method of straight-edge, square and level was insufficient.

There is no part about the locomotive of equal importance to the piston, which has received so little intelligent thought and attention. Piston heads worn much smaller than the cylinder diameter, out of alignment, fitted with badly designed and constructed or worn-out packing rings, and used in cylinders out of bore and round, have entailed loss in tractive power, and contributed toward boiler failures and maintenance expense to an extent not generally known. A piston is not accessible for constant inspection, and should be of a strong and light design and constructed of the least number of parts. The solid type kept closely fitted to the cylinder bore, and provided with two or three accurately fitted and grooved steam balanced snap packing rings of good design, material and construction, when given ordinary attention, will meet the requirements for wear and high steam pressures about as well as any arrangement that has yet been produced for locomotive service.

In general terms it may be said that the bacterial purification of sewage is brought about somewhat in the following manner: The micro-organisms already existing in the sewage are carried by it into the septic tank, and afterward on to the bacteria beds. These latter provide an enormously extended surface for the development of bacterial growths, and in this way furnish an ideal habitat for the aerobic bacteria to perform their natural functions, while the septic tank with its limited supply of light and air enables the anaerobic micro-organisms to carry on their work to the best advantage, and so to prepare the sewage for subsequent treatment on the bacteria beds. It is found that some time must elapse before the necessary bacterial life in the septic tanks and bacteria beds attains its maximum, and, as a consequence, the purity of the effluent increases with age. It is seen that the underlying principle of the bacterial purification of sewage involves two distinct stages in the process of disintegration. First, there are the anaerobic changes akin to putrefactive processes occurring in the septic tank, and subsequently follows the aerobic changes, corresponding to what is known as nitrification, taking place in the contact beds or percolating filters. Although the two classes of organisms may carry on their work to a certain extent side by side, it appears that the rate at which each process proceeds is more rapid when the two stages are kept as distinct as possible, which doubtless is one of the contributing causes of the more rapid action of bacterial filters over land. In broad irrigation the distinction between these stages is less marked, but the same two actions occur —the aerobic at the surface of the soil, and the anaerobic lower down.

Instructive

Scientific Papers

On Timely Topics

Price 10 Cents each, by mail

ARTIFICIAL STONE. By L. P. Ford. A paper of immense practical value to the architect and builder. Scientific American Supplement **1500.**

THE SHRINKAGE AND WARPING OF TIMBER. By Harold Busbridge. An excellent presentation of modern views; fully illustrated. Scientific American Supplement **1500.**

CONSTRUCTION OF AN INDICATING OR RECORDING TIN PLATE ANEROID BAROMETER. By N. Monroe Hopkins. Fully illustrated. Scientific American Supplement **1500.**

DIRECT-VISION SPECTROSCOPES. By T. H. Blakesley, M.A. An admirably written, instructive and copiously illustrated article. Scientific American Supplement **1493.**

HOME MADE DYNAMOS. Scientific American Supplements **161** and **600** contain excellent articles with full drawings.

PLATING DYNAMOS. Scientific American Supplements **720** and **793** describe their construction so clearly that any amateur can make them.

DYNAMO AND MOTOR COMBINED. Fully described and illustrated in Scientific American Supplements **844** and **865.** The machines can be run either as dynamos or motors.

ELECTRICAL MOTORS. Their construction at home. Scientific American Supplements **759, 761, 767, 641.**

THE MAKING OF A DRY BATTERY. Scientific American Supplements **1001, 1387, 1383.** Invaluable for experimental students.

ELECTRICAL FURNACES are fully described in Scientific American Supplements **1182, 1107, 1374, 1375, 1419, 1420, 1421, 1077.**

MODERN METHODS OF STEEL CASTING. By Joseph Horner. A highly instructive paper; fully illustrated. Scientific American Supplements **1503** and **1504.**

THE CONSTITUTION OF PORTLAND CEMENT FROM A CHEMICAL AND PHYSICAL STANDPOINT. By Clifford Richardson. Scientific American Supplements **1510** and **1511.**

Price 10 Cents each, by mail

Order through your newsdealer or from

MUNN & COMPANY

361 Broadway **New York**

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of The Supplement, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of The Supplement can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

Combined Rates.—One copy of Scientific American and one copy of Scientific American Supplement, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,

361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—How to Make a Gliding Machine.—By Livingston Wright and Gordon Johnson..... 25353

II. AGRICULTURE.—Surveying on the Farm.—By A. S. Kenyon. —6 illustrations..... 25352

III. CIVIL ENGINEERING.—The Possibilities of Concrete Construction from the Standpoint of Utility and Art.—By William L. Price..... 25351

IV. ELECTRICITY.—Electrical Notes..... 25355
How a Great Telephone System Is Designed.—By J. J. Carty.... 25347
Lightning and the Electricity of the Air.—By Alexander G. McAdie.—11.—7 illustrations..... 25347
Some German Electrically-operated Cranes.—By Dr. Alfred Gradenwitz.—4 illustrations..... 25342
The Rise of Electrostatics..... 25342

V. ENGINEERING.—Engineering Notes..... 25356

VI. MINING AND METALLURGY.—Molding Sand.—By H. E. Field..... 25346
Valuable Alloys.—III..... 25354

VII. MISCELLANEOUS.—Celluloid and Galalith..... 25350
Reservoir, Fountain and Stylographic Pens.—III.—By James P. Maginnis.—38 illustrations..... 25344
Science Notes..... 25356

YOU NEED IT!

Modern Gas-Engines

AND

Producer-Gas Plants

By R. E. MATHOT, M.E.

314 Pages **Bound in Cloth** **152 Illustrations**

Price $2.50, Postpaid

A Practical Guide for the Gas-Engine Designer and User.

A book that tells how to construct, select, buy, install, operate, and maintain a gas-engine.

No cumbrous mathematics: just plain words and clear drawings.

The only book that thoroughly discusses producer-gas, the coming fuel for gas-engines. Every important pressure and suction producer is described and illustrated. Practical suggestions are given to aid in the designing and installing of producer-gas plants.

Write for descriptive circular and table of contents.

MUNN & COMPANY, Publishers

361 Broadway, New York